FLOODS IN UTTAR PRADESH
A GEOGRAPHICAL PERSPECTIVE

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BY

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CERTIFICATE

This is to certify that the dissertation "FLOODS IN UTTAR PRADESH: A GEOGRAPHICAL PERSPECTIVE" has been completed by Miss Rashida Khatoon under my supervision for the award of the degree of Master of Philosophy in Geography.

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INTRODUCTION : Environmental hazards is global problem of growing importance. Those due to natural processes are alone thought to be costing mankind too much. Much of this destruction and death is the result of climatic events like floods, cyclones, drought, glacier as well as non-climatic hazard like earthquake. There is in addition a rather less significant group of hazardous processes which includes volcanic activity, snow avalanches, landslides and frost.

Rivers have caused civilizations to rise and to fall. They once dictated man's destiny, but now increasingly, it is we who control the worlds rivers. Our basic water supply comes from the surface water streams and rivers, even though this amounts to less than one percent of all available fresh water. The rest is locked in polar ice-caps or below ground. For 5000 years, people have modified rivers to tap their waters, solve flood problems and to exploit them for the benefit of agriculture and navigation. The scale of modifications accelerated at first in Europe, from about 1700 and, since 1950, changes have been dramatic world-wide. Truly man-made rivers have been created, vast ecologically rich wet land systems have disappeared and the fauna and flora of the rivers themselves have been markedly altered. During the past decade the approach to river development has become more environmentally sensitive. Today the aim is to control development so as to ensure that the river itself is maintained while adverse effects on other resources are, wherever possible, reversed.

Since about 3000 B.C., when the earliest civilizations were established on Nile, Tigris Euphrates and Indus rivers, there has been a close relationship between the control of rivers and socio-economic development. Rivers were tamed for the benefit of agriculture, i.e. early flood plain farming using the natural seasonal flow variation to water agricultural land. Evidence of hydrologic engineering in the form of irrigation ditches, dating back to 3200 B.C. has been found in Egypt. The earliest known dam was built at Sadd el Kafara before 2459 B.C. in Egypt. In China irrigation agriculture was well established by 2000 B.C. By the time of the Qin Dynasty (Ca 250 BC) hydraulic engineering, including river channelization projects for navigation and flood control was well developed. By 1900 most of the large European rivers had been channelized for navigation, flood control and reclamation. By 1940, policy for the impoundment of entire rivers to provide more reliable water supply, flood control, hydroelectric power and improved navigation was introduced by the Tennessee valley Authority.

Floods are not a newly invented phenomenon sent to afflict only modern man. Their occurrence has been common since the first rivers formed. Ancient man was so impressed with floods that they became an important part of his legends and religion. Man is trying to adjust to flooding and the damages it causes since then as well. Not only do floods cause grievous harm to man, his belongings and his property but, in some cases, man can also be the instigator of floods as well as the cause of their amplification. There can be several causes and types of flooding. They can result from excessive precipitation or from the bursting of a dam. Unlike other geologic hazards, floods affect only lowlands. Floods affect more people than all other hazards combined.

India is no exception from this hazard. Floods occur almost every year in some part of the country or another. Because of the extreme seasonal and spatial variability of water resources in India the rivers are prone to floods. All river basins are prone to floods in view of the extreme variability of the monsoons but the Brahmaputra and the lower Ganga river basin are subject to serious floods every year. Uttar Pradesh, Bihar and Bengal are the most affected states of India whereas other states do suffer as well.

In Uttar Pradesh floods have most frequent occurrence in the eastern districts because of the greater rainfall and because of the decrease in the gradient of river channels. This is an area of dense population and it is observed that the intensity of floods is increasing with passage of time and with greater loss. Considering the gravity and importance of the floods the author has tried to study river regimes, causes of flooding, extense of damages from floods and analyse possible measures to minimize and control the fury of floods.

CHAPTER - ONE

ENVIRONMENTAL HAZARDS

The life of man is closely related with the environment which helps in various ways but at the same time may pose a danger to his well being and survival. The forces x which endanger man's survival are known as hazard and as such have attracted the attension of almost all the sections of society. They are threat to humans and to what they value in life, well-being, material goods and their surroundings man exists in an essentially ecological relationship with his environment and is able to insulate himself from environmental threats. The variability and complexity in neutral and human systems can make some phenomena for example a river, both a hazard and a resource. It is so because society has learnt from experience and prepared itself to cope with repetitions. Nevertheless environmental hazards due to natural processes are alone thought to be costing mankind too much. Much of this distruction and death is the result of climatic events like floods, cyclones, drought, glacier as well as non-climatic hazard like earthquates, There is in addition a rather localized group of hazards which includes volcanic activity, snow avalanches, landslides and occurrence of frost.

A systematic and quantitative world view of exposure to a series of hazards reveals that tro pical Third world countries are more at risk. However a highly urbanised industrialised society within a specialied economy may well suffer in material terms much greater damage to buildings, industries and complex communication systems than a subsistance agricultural area in a developing country. So environmental hazards constitute a world problem of growing importance.

Hazards have been defined in different way at different times. Burton and Kates (1964) defined hazard as 'those elements of the physical environment harmful to man and caused by forces extraneous to him.' Gardiner (1977) defined it as 'events, objects, processes and substances that are perceived to cause more damage to or impose more costs on, society than benefits they give' and for the purpose of a symposium in Australia in 1976, as 'those extreme geophysical events greatly exceeding normal human expectation in terms of their magnitude or frequency and causing major human hardship with significant material damage to man and his works and possible loss of life? By definition then a, hazard is a function both of the physical event itself and of the state of human society, including specifically the adjustment adopted to cope with the hazard and the state of preparedness. A useful working definition of environmental hazards suggested by Kates (1978) is the 'threat potential posed to man or nature by events originating in or transmitted by the natural or built environment.[1] As Hewitt and Burton (1971) have stated,'the side effects of our technology are now coming to the forefront as a new class of hazards in their own right.[2] By concentrating wealth and population, urbanisation undoubtdly increases the damage potential of specific sites.

The extreme geophysical events collectively referred to as natural hazards stand near one end of a spectrum of phenomena ranging from natural to humanly-induced hazards. There are a range of hazards which are largely the result of human action often the result of man's modification of natural systems, which are transmitted through the natural processes of the environment that have come to be known as environmental hazards.

Hazards can be grouped into two in sets. The first group will consist of meteorological and hydrological hazards dealing with storms, snow, frost, fog, cold, floods and drought, and fog as hazards. The other group will have

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1. Perry, A.H., Environmental Hazards in the British Isles, LONDON, 1981, pp. 3.

2. Ibid P.5.

other types of environmental hazards like pollution, seismic, geomorphological and pedological, biological hazards.

FOG : The occurrence of fog is associated with meterological conditions which are conducive to the cooling of air below its dew point. Radiation fog and smoke fog most commonly occur during anticyclonic spells and col situations when winds are light, while advection fog over coasts is usually associated with moist south-westerly air streams. Advection fog inland may occur in winter when mild air is advected across a cold, snow-covered land surface. Fog in simple terms is defined as occuring when visibility is less than 1000 m irrespective of whether the obscurity is produced by water droplets or solid particles.

Fog is likely to be most hazardous when it is thick and this objective is used by meteorologists when visibility is less than 200 m. The term 'dense fog' is used when visibility is less than 50 m. The nature of fog varies with temperature variation. Fog occurrence is affected by topography and large variations in visibility over short distance are quite common. Radiation fog in particular, is often a localized phenomena and tends to be erratic in development and localised in extent. Two types of fogs are common.

a) Warm fog - which consists of a cloud of droplets which have a temperature above $0^{o}C$.

b) Supercooled fog (sometimes referred to as freezing fog)

The droplets are in equilibrium with the atmosphere at a temperature which is equal to or less than $0^{o}C$.

Fog is a hazard to transport by land, sea and air and costly adjustments such as automatic aids for aircraft and safety signalling for rail transport are needed.

SNOW, FROST AND COLD :

Snow, frost, and cold weather occur in most winters, but most frequently constitute a hazard when they occur over protracted periods or during the latter part of the spring when they can severly damage growing crops. Because severe winter weather is relatively infrequent in its occurrence, investment in preventative measures is inadequate to cope with conditions on such occasions.

A major impact of snow hazard is manifested in the disruption of transportation facilities and even small accumulations can curtail movement and contributed to accidents in a mobile society. Although less severe, spring radiation frosts can do far more damage than those of winter, because they occur when growing crops are highly susceptible.

HAIL :

Although sometimes severe, convective hail storms are often highly localized and may cause damage in one area, while a neighbouring area remains quite unaffected. Hail stones are normally less than about 10 mm in diametre and causing sufficient damage to growing crops, to glasshouses, or to seriously dent motor cars.

THUNDERSTORMS : The most frequent casualties from lightning include people outside in open countryside or sheltering under trees. In the most thundery areas, standing trees that have been killed by lightning are a fairly common sight. T.V. antenna are quite frequently struck and can result in expensive damage to the T.V. set. Lightning strikes to earth can also result in faults developing in the electricity supply system.

The cause of severe storms are instability through a deep layer of the atmosphere together with strong surface heating. These conditions are most common with slow moving cold fronts or troughs or with low pressure.

TORNADOES AND CYCLONS: Tornadoes, the most violent and localised type of storm. Apart from damage caused by severe vertical and horizontal air currents, damage of an explosive type may occur when a tornado passes, in the middle of the tornado walls and windows may burst outwards severely damaging buildings and roofs can also be sucked off.

Water spouts are similar to tornadoes but they form over the sea. They are observed quite frequently in coastal waters and have caused damage to harbours and boats on several occasions.

Most kinds of storms are of high intensity but often of short duration.

GALES : The wind hazard results from both the direct and indirect effects of air in motion. Gales are the cyclonic storms or depressions with steep pressure gradients passing over any place while the other types of storms are principally the result of convective processes in the atmosphere. So far as gusts are concerned there is much less difference between inland and coastal stations. Wind speeds are infuenced by local topography and strong winds tend to blow even more strongly along a valley if the valley runs in the direction of the wind the so called 'funnel effect' statistics show highest wind speeds in three geographical locations upland areas, coastal areas, and inland areas. If rain falls when the wind is blowing, raindrops will be carried along horizontally at approximately the speed of the wind.

Engineering works and buildings are subject to structural damage as a result of wind stress. Economic pressures have resulted in a trend towards buildings of light and slender construction, but some modern tall buildings have an unacceptable performance when buffected by the wind with perceptible motion causing distress and discomfort in the building. Wind loads on strcutures are conveniently divided into static and unsteady (time dependent) loads. For design purpose the engineer today needs to know the estimated return periods of various wind speeds.

Falling or flying debris is frequently responsible for casualties and trees falling into dwellings and cars represent a particular hazard during gales. On roads light vehicles can be blown into the path of other traffic.On major roads, and especially on highways cross-winds can be hazardous for high-sided vehicles such as furniture vans and on exposed bridges. A vehicle emerging from a tunnel, cutting or bridge which is then suddenly hit by a strong sidewind is particularly susceptible to wind. The wind has a direct effect on both the reliability and safety of railway operations wind damage to crops and vegetation is severe.

<u>FLOODS</u> :'The rains descended and the floods came' Mathew 7:25

Hydrologists define river floods in terms of frequency. Thus the annual flood would be the largest flow during a year, or in terms of the geometry of the river channel. Hewitt and Burton (1971) have suggested 'harmful inundation of property and land utilised by man'[3] while Ward suggests - 'a flood is a body of water which rises to overflow land which is not normally submerged.[4]

The flood hazard is the joint product of physical and human factors and flooding is as much an economic problem a hydrological one. In the case of rivers, the low lying flood plain bordering the river is susceptible to inundation but the floodplain exhibits natural site factors which in many instances have made it an attractive settlement site. By responding to these factors and attempting a land use which is not in harmony with the hydrological cycle, man is subject to the flood hazard, although he frequently seeks to reduce the flood threat by investing in preventive measures.

The meteorological conditions leading to inland flooding involve intense precipitation, prolonged precipitation or snowmelt, either singly or acting in combination. There is evidence that the occurrence and frequency of heavy rainfall may also be greater over urban areas as a result of increased roughness, the role of pollutants

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3,4. Perry A.H. Environmental Hazards in British Isles, London, 1981, p.70.

in providing condensation nucleii and more active thermals as a result of the urban heat island.

The character of the catchment will determine the response to heavy rainfall and the effect of some physical catchment parameters which can lead to flood intensification should be considered. The main flood intensifying conditions can be grouped under the headings of basin network and channel characteristics, each group having some characteristics which are stable and others which are more unstable. Of the stable basin charcacteristic shape is one of the most important. Acompact circular catchment can lead to larger concentrated floods in the low section. Geology, soil type and vegetation variations are especially important variable basin characteristics. Impervious catchment will produce a great amount of surface run off, while permeable and pervious rocks have a capacity for water storage. Drainage patterns which result in the coalescence of flood flows from a number of tributaries in the lower part of the drainage basin can result in high magnitude flood peaks at the basin outlet. The channel characteristics affect the passage of floodwater down stream and in particular roughness of the bed and bank affect the velocity and magnitude of the flood.

DROUGHT : Droughts are not sudden emergencies with little or no warning, as is often the case with such hazards as floods and in general they can be defined only when they are well underway. Drought is potentially a serious threat to economic activity. Droughts are natural events but water shortages result from inadequacies in facilities. Droughts should be defined in terms of the relationship between the natural event system and the human-use system; the unexpected deficiencies in the moisture supply from the meteorological and hydrological systems of the environment as compared with the demands of the human resource use in that environment Drought can be defined objectively in numerous ways to suit particular purpose and Tabony (1977) has presented arguments for the use of indices which differentiate between meterological hydrological and agricultural drought. Whatever objective indices are used to classify droughts the root cause of drought is a rainfall deficiency of considerable duration and Hewitt and Burton (1971) have defined the drought hazard as 'a period in which moisture availability falls below the current requirements of some or all the living communities in an area and below their ability to sustain the deficit without damage, disruption or excessive costs.'[5]

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5. Perry A.H., Environmental Hazards in British Isles, London, 1981 pp. 101-102.

Droughts cannot be prevented from occurring and the major protection against them involves the storage of water either underground in groundwater reserves or in surface reservoirs.

<u>GLACIERS</u> : Glaciers are at present in a contracted state and most do not appear particularly threatening. People may know something for example the dangers posed by crevasses, but have little appreciation of those more important hazards which are due to glacier fluctuations. Yet, were there to be even a small climatic deterioration, those same glaciers would expand, as they have on several previous occasions and would become more hazardous to mankind.

Glacier-man relationships are constantly changing These relationships are also influenced by the modern tendency to push settlements and economic development ever closer to the limits of the habitable world. Thus various kinds of human activities are still being undertaken within historic glacier limits, sometimes this means the creation of fresh hazards.

Process of destortion usually involves more than the overrunning of a settlement by an expanding body of ice. For example morainic debris may be pushed against buildings shortly before the ice actually reaches them. Other hazards are caused by glacial meltwater streams. Further problems arise when ice falls from a glacier on to nearby building.

Glacier expansion occurs more slowly and is less violent than ice avalanching and glacier flooding. Even when surging, glaciers give ample warning of increased danger and so pose virtually no threat to human life. There is usually time to dismantle a property which is at risk.

Glacier floods arise due to various reasons. In some cases they are due to the rapid escape of water which has been impounded behind a dam of ice and perhaps, moraine. The events leading to this type of flood may begin when climatic deterioration induces a side valley glacier to expand towards the main valley at a point where this is ice-free. If the junction between the two valleys is markedly discordant, ice may break away from the terminus of the expanding glacier, avalanche into the principal valley and form a regenerated glacier at some distance from the parent ice body.

When water rapidly escapes through or under the ice dam, its passage is aided by the existence of crevasses and other openings within or beneath the glacier. Such events can cause an ice-dammed lack to be totally drained. Because of these various means of lake discharge water level in such features is characterized by numerous and often rapid changes which may lead to flooding that extends many kilometres downvalley.

These constitute a more serious threat to mankind than do the other glacier hazards, for they have a history not only of destroying property, but also of causing injury and death to people as well as animals and plants. Also, they can have substantial geomorphological effects and often extend their havoc much further beyond the edges of ice-covered areas than do other glacier hazards. The most deadly ice avalanches are those whose occurrence is unpredictable, because they are the product of factors which combine on an irregular and usually well spaced out time-scale.

The other set of hazards related to pollution, seismic, geomorphological and pedological and biological hazards.

POLLUTION : Pollution is defined as the release by man of substances (or energy) to the environment in quantities which damage his resources. It can also be regarded as a form of resource misuse arising because individuals can transfer the costs of removing their waste products to others. Recently there has been an increased concern shown for environmental quality and a general recognition that pollution of all sorts impairs the quality of the environment. The effects of pollution can be dramatic, as in the case of severe air pollution episodes with their attendant rise in the death rate or less obvious and more circumstantial, for e.g. the higher death rates from certain diseases in areas of heavy metal contamination. In addition new technologies are constantly resulting in new pollutants. It is better to deal with different types of pollutions in detail.

Air Pollution : Air pollution may be defined as short-term period of consecutive days during which the ground-level recorded concentrations reach exceptionally high levels, which can be both dangerous and economically costly to the community. Two conditions are needed to produce an air pollution episode; one is the emission of sufficient quantities of pollutants and the other is the necessary adverse meteorological condition to cause the emitted pollutants to reach high ground level concentrations. When the temperature increases with height in the first few kilometres of the atmosphere conditions are said to be stable, and such conditions prevent vertical dispersion, trapping pollutants close to the surface. Being a health hazard air pollution exacts an economic tole. Pollution corrodes metals, damages building surfaces and is injurious to human health, vegetation and crops.

Water Pollution : River pollution occurs almost entirely as the result of effluent disposal and since the potential exists for typhoid, poliomyetitis and dysentry epidemics to be spread by water pollution it is better to include it as an environmental hazard. Domestic sewage effluent is the most important source of water pollution. There are still many rivers which have middle and lower reaches where the dissolved oxygen (DO) level in the water is so low that the capacity of the river for self-purification is minimal and objectionable. Pollution problems associated with agricultural wastes and especially run off from areas dressed with nitrogen and phosphorous fertilisers and toxic pesticides occur in some parts of the country and episodic fish kills have been caused by accidental discharges of such materials.

Land and Industrial Pollution : The pollution of land is generally localised in particular areas such as waste disposal tips. Ground water resources can be polluted by percolating water from waste tips, although sand and gravel can be used as a natural filter.

The biological implications of heavy metal contamination are presently unknown although many authorities now subscribe to the concept of sub-clinical metal poisoning leading to subtle derangements of the metabolism, Incidence of stomach cancer, multiple sclerosis, pernicious anaemia and other diseases shows strong evidence for linking the presence of heavy metals in soils with these diseases. Minerals like cadmium and lead are toxic, while copper and zinc, although essential for life processes, are toxic when present in excess.

The petrol engine is an important source of lead in the environment since organic lead is added as an anti-knock agent to petrol and this emerges in particle form in exhaust fumes contaminating soils in urban gardens, parks and allotment as well as near to motorways and main roads.

Noise pollution : Noise is an important pollutant in urban areas. Noise is unwanted sound and is also tought to be as wasted energy. Noise is one element of urban stress, which itself produces behavioural and physiological consequences. The major source of noise in general are :

a) Industry, transporatation and Residential activities.

SEISMIC HAZARD :

With the building and proposed building of important sensitive structures such as nuclear power station, there is need for evaluating the seismic hazard. Because nuclear waste storage requires sites of great geological stability. Geological stability is very important for structures like dams, etc because seismically unsound area leads to disasters such as flash floods.

GEOMORPHOLOGICAL HAZARD : The mass movement of land may produce hazardous situations, mainly as a result of human actions on land and due to marine erosion on coast. Slow but inexorable movement over a long period of time is unlikely to produce serious trouble, but it is the violent displacement under the action of gravity on an unstable slope that can produce movements such as landslides which most frequently create a hazard. Torrential rain mostly provide ideal conditions for mass movement and landslides. Rockslides and rockfalls occur where a steeply sloping rock face is formed of a well jointed rock, such as is the case with many limestones. Mining activity is also to some extent responsible for landslides caused by the natural agents of denudation. Silting of ports and harbours create a very different type of coastal hazard which is provided by the movement of coastal sand dunes.

PEDOLOGICAL HAZARD : Pedological hazards are seen in the form of soil erosion. Most erosive processes are accelerated by man and soil erosion probably began with the clearance of the vegetation for agriculture. Erosion is related to crop and land management in the same way as is related to physical factors. Changing farming practices, including the elimination of grass fallows is exposing a larger proportion of the farm area to erosion. Removal of hedges and other protective barriers has increased field size sometimes facilitating erosion. Soil erosion by water may take the form of sheet erosion, rill erosion or gully erosion. Degeneration of the vegetation cover by burning, overgrazing or recreational pressure often causes accelerated erosion on hillsides. The loss of vegetation cover leads to poorer sheep grazing and less wildlife.

BIOLOGICAL HAZARD : Biological hazards are seen in the form of health hazard for man. Disease is lack of harmony in the environment with the response conditioned by the genetic make up of the individual. The environment provides man with his essential life-support system but side by side it also presents him with a variety of hazards. Mostly diseases are the result of some factors or factors in the environment. Today the heights are that even people die due to polluted drinking water. In our own health consciousness, we tend to forget that the common housefly can carry about forty serious diseases while other pests continue to represent a hazard to man. Even the modern passanger jet aricraft allows their wash basin water to be discharged into the atmosphere, while all waste from lavatories is disposed from rail straight on to to the track. All this causes epidemics. Environment could be linked with the respiratory illness, suffered by those exposed to the measured parameters. Many people suffer much distress from their hypersensitivity to a wide variety of pollens and dusts which are present in the environment.

Animal and Plant hazard : Pollution today has reduced resistence of trees to diseases. Modern forestry techniques and a massive use of herbicides also play a role in reducing resistence. Environmental hazard pose a risk of potential disaster. Hazardous events include threat to person, morbidity and mortality as well as damage to activities and wealth, both natural and man-made.

The solid surface of the earth, which is the home of man, is continuously changing and has changed dramatically within the life-history of mankind. The pulsating nature of climate is responsible for maintaining the cyclic change. But how sensitive is agriculture to the variability of climate. Floods and droughts often appear as disasters to upset life every year in one or the other part of the world. Therefore, even within the frame work of human time-scale nature should be seen as a system having its own mechanisms to maintain equilibrium as also to sustain change therein.

Man is sustained by other species in his environment crops, domestic animals and fish and if there is a significant ecological disruption on a wide enough scale through pollution man himself cannot escape the hazard.

CHAPTER - TWO

REVIEW OF STUDIES ON FLOODS

Flood as a hazard have attracted the attention of a number of scholar from various disciplines like geomorphologist, engineers, geologists, economist, ecologists and geographers. Everyone has tried to study the problem according to his own requirement. Such studies relate to floods occurring in different rivers of the world and range in form from topical studies to regional accounts. United Nations organisation has or been concerned with the floods and brought out a series of publications analysing the extent of flood damage and measures for flood control in different countries and rivers of the world.

In the portion relating to the river Ganga the United Nations Report on Floods (1950) points to the fact that this river in its upper reaches is quite stable. With the result that no embankments have been constructed along it course upto its confluence with the river Ghaghara. However, in certain portions the river overflows the natural levees during monsoons when it is flooded. For example near Allahabad its left bank is flooded to a distance of about 8 Kms and the floods last for a few days.[1]

A study made by the United Nations Flood control committee (1951) finds that both spur dikes and longitudinal

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1. "Flood damage and flood control activities of various rivers of the region. Ganges River", <u>Flood Damage and flood control activities in Asia and For East (Flood</u> control Series) No. 1, 1950, p.29.

revetment are used in India in some places along the rivers as a measure of protection against floods. The width of such an apron depends on the likely depth of thex scour. The study also reveals that in Indonesia the condition is different from other countries of the region. In the densely populated plains of Java, the flood problem has been solved by the construction of dikes and by the drainage improvement plus the construction of flood diversion canals. In Thailand defence against flood is adopted by using a crop to fit flood condition.[2]

Enayat Ahmad (1952) presented a detailed assement of floods and their frequent occurrence in Eastern districts as a result of greater rainfall and a decreasing gradient of river channels. The river Gomti is often in spate in its lower course, where a narrow channel results in the overflow of water. Similar character is observed in the floods in Trans-Ghaghara plain which receives water from Rapti, Sarda and Ghaghara rivers. Only elevated land of village settlements remain above water and looks like an island between the surrounding flood water. This almost imperceptible unevenness in the overall level plain where

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2. "Review of flood control methods employed in the region," Methods and Problem of Flood control in Asia and the Far East, Flood control series, No. 2, U.N. 1951, PP. 10-15.

the village settlement is established is associated with the process of alluvial formation of theplain.[3]

Floods have also attracted the attention of governmental agencies in Japan where the River Bureau, Ministry of construction pointed out that the rivers in Japan are more often subjected to floods because of precipitous slopes in the mountainous topograpny leading to increased velocity of rivers. In addition the island of Japan lies just on course of typhoons and is thus beset with heavy rains in summer and Autum, due to which rivers repeatedly cause destructive floods.[4]

Another United Nations Report (1953) highlights that sediment deposition is a trouble some process along rivers and streams as it raises stream beds, thereby increasing flood heights and inundation and piles up sediments in immense quantities behind dams, reducing their capacities and function. The sediment deposition also forces the river to meander and often to leave its original course and flow along new course, devastating vast areas of excellent land. Main cause of sediment trouble is an

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3. Ahmad, E. "Rural settlement types in the Uttar Pradesh," Annals of the Association of American Geographers, Vol. 42, 1952, p. 236.

4. "Flood control in Japan," Proceeding of the Regional Technical conference on flood control in Asia and the Far East, River Bureau, Ministry of construction Japan, 1952, p. 147.

accelerated soil erosion in the catchment areas of the rivers.[5]

Luna B. Leopold and Thomas Maddock (1954) pointed out that Flood control does not mean the elimination of flood, but at best it can provide certain amount of protection against overbank flows. The upstream phase consists of conservation practices and structures on watershed lands. The downstream phase involves major reservoirs, levee system and related installations in major river valleys.[6]

Fung Ching-Yue, discussed (1956) that the diversion floodways, channel improvments and levees are effective means of flood control. They may be combined with a storage project. All of these are subject to topographical and economical limitations usually due to cost limitation or otherwise, flood control cannot be completely effective by any one of them alone. If the storage is operated satisfactorily, crests of all floods are reduced.[7]

Henry C. Hart (1956) made a study about men at work on Indian rivers and came to the conclusion that in view of physical dimensions involved, the job of harnessing

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5. " The sediment Problem", <u>Flood control series</u> No.5, U.N. 1953, PP. 7-11.

6. Leopold, Luna, B and Maddock, T. <u>The flood control controversy</u>, 1954, New York, p. 9.

7. Fung-Ching-Yue, Flood control in relation to the justification of a multi-purpose project, <u>Proceedings of the Regional Technical conference on water Resources Development in Asia and Far East</u>, Flood control series, Bangkok, No.9, U.N., 1956, P. 85.

India's rivers is one of the largest on earth. He has evaluated the work and suggested the possible ways for dam construction engineers to attain better results.[8]

Johns V. Krutilla and Otto Eckstein (1958) in their study revealed that in order to provide protection economically for a single occupant of an exposed reach of the flood plain, a given irreducible dose of investment, which may at times be very large, is required. The flood control involves a collaboration effort from various interdependent units and requires therefore a common investment because the system functions as a set of complementary facilities. Flood protection is a job which may not satisfy the needs of every individual involved but is decidely a step towards river development.[9]

West Bengal is one of the flood prove areas of India and has thus been attracting the attention of different scientist. Chatterji, S.P. (1961) an eminent geographer has found that the floods in west Bengal are mostly a function of three variables: Precipitation, terrain and run off. If

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8. Hart, H.C. New India's Rivers, Calcutta, 1956.

9. Krutilla, J.V. and Eckstein, O. Multi Purpose River Development, U.S.A., 1958.

the intensity and duration of rainfall are short and the catchment area is restricted, the flood are not alarming but have local importance only. But if the storm centred over the interior portion of the plateau or the central delta, the resultant precipitation causes inflation of the lower reaches quickly. The run off from the head portion is later on added to that which has been caused in the lower reaches and increases the gravity of the situation. This phenomenon futher delays the disposal of floodwaters. It has been found that most of the floods in West Bengal are due to strengthening of the monsoon current over the sub-Himalayan Bengal. Any flood control measure should consider how best to reduce the load upstream and stabilise the course lower down. The run off is another important item determining flood intensity. The run-off is affected by the texture and slope of the ground on which the water moves and the period for which precipitation takes place. Afforestation and contour ploughing are likely to reduce the rate of run off and contribute to flood prevention.[10]

Ian Burton (1962) studied typology of agricultural occupance of flood plains in the United States. The typology is based upon a synthesis of two main lines of reasoning

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10. Chatterji, S.P. "Floods in West Bengal - A Geographical Study", Geographical Review of India, Vol.XXIII, Sep. 1961, No. 3. pp.1-6.

in which possible relationship between selected characteristics of the flood plain environments and two main aspects of occupance are described, and secondly the regularities in agricultural occupance of flood plains are observed over a range of selected flood plains. It is regarded that flood losses or adjustments to flood hazards as a special part of the costs of production are higher on the flood plain.[11]

Robert, W.K. (1962) throws light on the way man view the risks and opportunities of their uncertain environment plays a significant role in their decisions as resource management. It also throw new light on the conditions under which men occupy flood plains and at the same time yield empirical evidence on decision making process.[12]

An intensive study of La Fallette, Tennessee and a reconnaissance study of five other towns differing widely in physical characteristics of flooding was conducted by Gilbert F. White, in 1964. In order to find ways of adjustment of man to a locality influenced by floods it is better to assess technicalfeasibility of particular adjustments,

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11. Burton, I, "Toward a typology of agricultural occupance of flood plains, Types of agricultural occupance of flood plains in the United States, 1962, pp.1-6.

12. Robert, W.K. Hazards and Choice perception in flood plain management, Chicago, U.S.A, 1962.

the economic efficiency of these choices and the timing and incidence of decisions by the private and public management experts.[13]

In the United States also the people using such land which is subjected to an always concerned with imperding dangers of flood. According to Gilbert. F. White, they suffer the loss from occasional overflow or are constantly looking after the protective dams. It is found that technical feasibility of several adjustments thus made differs in many ways according to frequency stage, duration and velocity of flooding.[14]

Rovert W. Kates (1965) discussed some new techniques to the problems of synthesizing industrial damage, arising out of floods. Careful guides for estimating economic losses, better models of land use change and provision for change in flood adjustments appear to be areas of improvement where efforts might yield high returns. For industrial firms, where the losses are large and the firm resources are substantial, considerable improvment in damage reduction behaviour might be obtained by advisory services of engineering

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13. White, G.F. Choise of Adjustment to Floods, Chicago, U.S.A., 1964.

14. Ibid.

and architectural consultants on flood damage reduction measures.[15]

Derrick Sewell W.R. (1965) after analysing technical and economic advantages has come to the conclusion that multi-purpose reservoir is perhaps the best way of over all river basin development. He also advocates that development for certain purposes, such as hydro-electric power and flood control, can often be accomplished most efficiently if the river is controlled from the headwaters to the sea. A basin wide plan is needed to be drawn up. Fraser river is major river of Canada and the lower Fraser valley is often subjected to great devastations. A solution to the problem was made to reconstruct the dyking system. A multipurpose development of Fraser River was seen as a solution to both flood problem and power problem.[16]

According to the Techno-Economic survey of Uttar Pradesh (1965) regarding the damage caused by floods it is estimated that the area affected is about 23 lakh acres during low flood years, 83 lakh acres by medium floods and about 100 lakh acres by heavy floods. The severly affected areas fall in the eastern districts of the state where

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15. Kates, R.W. Industrial flood losses: Damage Estimation in the Lehigh valley, Research Paper No. 98, Dept. of Geography, Chicago, 1965.

16. Derrick Sewell. W.R., Water management and floods in the Fraser River Basin, Research paper No. 100, Dept. of Geography, Chicago, 1965.

precipitation is generally heavier and the area has almost a level topography. Lack of adequate drainage facilities is also a serious problem in certain areas of the state.[17]

Fluctuations in the velocity and discharge of rivers result from variations in precipitation and temperatures Such fluctuations according to Grover N.C., and Harrington A.W. (1966) are influenced by the rates of snow melt, the intensity and areal extent of rain and the slope and geological character of the river basin. The rate of melting snow and the intensity of rainfall are the factors which directly affect the fluctuation of rivers.[18]

According to Kumra, P.N. (1968), a river in flood spills over its banks due to inadequacy of its normal channel to carry the high flood discharge. Magnitude of flood damage depends upon the depth and duration of the spill and nature of the configuration of the area. The term flood control does not guarantee immunity from flood but means flood protection to certain extent. Flood control methods are administrative and involve engineering application.[19]

Gordan Wolman, M. and Luna B. Leopold (1970) made studies of a number of flood plains in the United States and in India,

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17. Techno-Economic Survey of Uttar Pradesh, New Delhi, 1965.
18. Grover, N.C. and Harrington, A.W, Stream Flows: Measurements, Records and their uses, New York, 1966.
19. Kumra P.N., "Flood Protection Methods in India," Geographical Review of India, Vol.XXX, No. 4, Dec.1968, pp.45-55.

indicate that the frequency of overbank flow is remarkedly uniform among rivers flowing in diverse physiographic and climatic regions. This study supports the view that flood plain is composed of channel deposits or point bars and some overbank deposits. The relative amounts of each vary but on the average the proportion of overbank material appears to be small. This conclusion is supported by the uniform frequency of flooding and by the small amount of deposition observed in great floods. The flood plain can only be transformed into a terrace by some tectonic, climatic or man-induced changes which alter the regime of a river, causing it to entrench itself below its established bed and associated flood plain.[20]

Chatterji G.C., Ramachandran and Roy (1971) discussed that the excessive rains in the month of october when the ground is already saturated and unable to absorb any more moisture cause unprecedented floods and landslides in north Bengal, Sikkim and Bhutan, steep slopes with insufficient vegetal cover generally with a thick soil mantle, underlain by highly folded, sheared and jointed incompetent schists, mica gneisses and phyllites for most part were already in a state of instability due to the above reasons, aided by

20. Wolman, G.M. and Leopold. L.B. Rivers and River Terraces, London, 1970.

toe erosion of hill slopes by major rivers.[21]

A detailed study of the Kosi river was made by made by Mookerji, D, (1971) wherein he pointed that the major problem was not only to control the floods but to confine the main river course to a predetermined state and preventing lateral movement of water for this purpose construction of embankments may be taken up and to check the source and volume of sand and reduce its quantity it was suggested to build check dams. Levee system to tame the river was also put up.[22]

An extensive study by Banerji and Lal in 1972 indicates that each river system has its own characteristic periods and causes of flooding. The study assesed the flood problem by considering physical and morphological features of Indian rivers. It is found that floods in Kashmir valley are due to its saucer shape. In Punjab, poor country slopes, high groundwater table and poor infilteration leads to inadequate drainage resulting in floods. In Himachal Pradesh flash floods carrying large silt load that chokes the channel

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21. Chatterji G.C, Ramachandran, Roy, S., "Landslides and floods in north Bengal and adjoining areas," Indian Journal of Power and River valley Development Vol.XXI, No. 2, Feb. 1971, PP. 45-47.

22. Mookerji, D, "The Kosi responds to treatment," Indian Journal of Power and River Valley Development, Vol.XXI, No. 9, Sep. 1971, PP. 317-324.

pose a problem. The Ganga river system in parts of U.P., Bihar, West-Bengal have a serious drainage congestion. In Brahmaputra river system, very heavy rainfall, and Seismic activity are the reasons. In Peninsular river system there is a serious flood problem in deltaic regions of Mahanadi, Godawari and Krishna. It was considered that floods may be natural and also man made; similar is the case with flood disaster.[23]

Dakshinamurti, Michael and Mohanshri, in 1973 jointly conducted that the best way to control floods is to intercept them with storage reservoirs, so that only moderate floods are allowed to flow through the valley below. Multipurpose project are best planned for flood control. The works carried out by the Damodar valley corporation in the Damodar river basin and various benefits conferred by them, are the result of such planning where the primary air was flood control.[24]

A comprehensive study by Bhattacharya (1973) in Damodar river reveals that the estimates for flood control by the original planners did not really take into account the needs of the drainage area of the Mundeswari channel in particular and lower re ches of the Damodar river in

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23. Banerji, S., and Lal, V.B, "Flood control in India, basin approach to the problem", Indian Journal of power and River valley Development, Vol. XXII, No. 10, Oct 1972, pp. 410-417.

24. Dakshinamurti, C., Michael, A.M., and Mohan Shri, Water resources of India and their utilization in agriculture, New Delhi, 1973.

general. The policy of reservoir operation by DVC authorities meant encroachment on the flood reserve of the dam. As a result the lower Damodar valley has a greater chance of being flooded in case of any sudden rise in the peak flow of Damodar waters.[25]

John A. Dawson and John C. Deornkamp, have a view (1973) that once the flood frequency is established, adaptation of land use to flood risk can be achieved. In New South wales heavy down pour lasting seven days causes widespread flooding along major rivers. The westward flowing streams experience a gradual downstream migration of flood wave, while the much steeper east coast streams experience rapid rises in levels and swift flood run off. Most modern cities have spread into flood plain in last 200 years. London expanded into the thames flood plains restricting the width of the river channel and making peaks naturally higher.[26]

In the opinion of Arthur N. Strahler and Alan H. Straller (1973) physical approaches to control floods are to detain and delay runoff by various means on the ground surface and in smaller tributaries of the watershed

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25. Bhattachrya A.K., "Flood control in the Damodar valley," Geographical Review of India, Vol. XXXV, No. 2, June 1973, pp. 136-147.

26. Dawson, J.A. and Doornkamp, J.C, "Studies of floods and flood plains," Evaluating the Human Environment, London, 1973.

and to modify the lower reaches of the river and its floodplain where inundation is expected. Besides these planting a vegetative cover, constructing small dams, levees etc may be practised. Retarding basin produced by construction of a low dam across the river is another engineering device which may be utilized.[27]

Simmons I.G. point out that one normal conditon of the hydrological cycle has been perceived as abnormal by man and labelled as floods. Poor watershed practises have often been exacerbated and in some places have been the cause of floods, but it remains true that most rivers have flood plains which get inundated from time to time with varying depth of water and at low levels of predictability. Flood control dams, channel widening, channel straightening and deepening and construction of by-pass channels are some remedies. But for all round ease, manipulation at the surface water phase of the hydrological cycle ranks first.[28]

Pannalal Das (1975) made a study of Kaliaghai river of Midnapore where engineering devices were a complete failure. The area lies at a crucial position in respect

27. Arthur N. Strahler and Alan H. Straller, "Subsurface water of the lands," Environmental Geosciences, 1973, pp.331-335.

28. Simmons I.G., The Ecology of Natural Resources, London, 1974.

of surface configuration, hydrology and slope due to which measures already adopted were likely to fail. Small fraction of sand and silt was washed down during floods and low land in this way was gradually being silted up year after year. This accumulating silt then proved a bottleneck and held up flood waters of the Kaliaghai. This results in the flooding of the upper areas. The flood problem of the Kaliaghai river is thus a problem of proper drainage.[29]

Panchadhyayi S, (1976) in his investagation of Subarnarekha Basin reports that the problem of flood in this area are accelerated by already unfavourable hydrological and climatic situation induced by runoff, intense rainfall, poorer absorption, unfavourable soil and soil erosion in the upper catchment, drainage congestion and tida in its mouth also have considerable impact on the flood incidence in the basin.[30]

It was suggested by Rao, K.L. (1979) that the discharge measurement of river are very important for developing, economically beneficial projects whether it be for irrigation, power production or flood control. In particular one should

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29. Pannalal Das, "An Appraisal of flood incidence of the Kaliaghai River Basin," Geographical Review of India, Vol. 37, No. 1, March 1975, pp. 73-81.

30. Panchadhyayi, S, "A diagnostic study of flood problem in the subarnarekha basin, " Indian Journal of Power and River Valley Development, Vol.XXVI, No. 10, Oct 1976, pp. 319-323.

know the maximum and minimum discharge, the total annual flows and their variation. Catchment areas themselves cannot give an idea of the magnitude of flows. Though the catchment area of Nile is nearly ten times the catchment area of the Godawari, the discharge is about same in both the rivers.[31]

Kayastha, S.L. and Yadav, R.P. (1980) made micro level study of socio-economic condition in Mubarakpur village which is in Ghaghara flood plain and it was evident that people of this flood plain have high degree of perception of flood-hazard. They use their own boats and only 5% cattle have been lost due to floods during the last fifty years. The social condition is not so good as their economic condition and this is mainly because they have developed a number of alternatives for checking their economic losses, such as keeping more livestock, raising the house level etc. But their social condition is badley disturbed as they have little education, poor housing condition and only a few modern facilities etc.[32]

Sharma A.A.L.N., and Rao S.D. (1981) made a rational approach to quantify the flood magnitude on the basis of

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31. Rao, K.L. India's water waelth, New Delhi, 1979

32. Kayastha S.L. and Yadav R.P., "Flood hazard in lower Ghaghara plain (U.P. India): A study in perception and impact on Socio-Economic development, National Geographical Journal of India, Vol.26, pts.1 & 2, 1980, pp.19-28.

water balance concept developed by late Prof. Thornth waite. So it was thought important to know the available amount of excess water over and above the water need. The amount of excess water (water surplus) that is available after meeting the demands of both the atmosphere and soil contributes to the surface run off. The large arrival or advancement of water is termed as flood and it differs from run off only in degree.[33.]

A citizens Report (centre for science and Environment), 1982 has identified only 17 dams out of 1154 dams as flood control projects in India. The report has highlightened the damages arising out of the construction of dams. Dams are incapable of absorbing heavy floods and have to resort to panic discharges, leading to destructive flash floods due to heavy siltation which reduces storage capacity. A high rate of siltation not only puts pressure on dams but it also deprives the plains downstream of nutritional benefits. Dams also increase incidences of diseases. Earthquakes are triggered due to the impounding of massive amounts of water. Tribal population are disturbed because these dams are mostly built in remote forested areas and the sudden influx of modern system of living creates problem to them.[34]

33. Sharma A.A.L.N., and Rao S, "Some climatic studies on the incidence of floods at selected stations of the river Mahanadi basin", Indian Journal of power and river valley Development, Vol. XXXI, No. 3 and 4, March-April 1981, p.42.

34. The State of India's Environment 1982
A citizens Report (centre for science and Environment) New Delhi.

According to the Times of India Directory and year Book 1982, as much as 60 percent of the flood damage is caused by the Himalayan rivers. The working Group on flood control for Sixth Plan (1980-85) set up by Planning commission has proposed an outlay of nearly Rs 16,000 million for this sector. This includes required outlay for modernising flood forecasting system and for floodplain zoning. In spite of these measures the damage due to floods has shown a rising trend.[35]

Kayastha, S.L., (1983) pointed out, floods result not only from the overflow of water but also on account of all other water that is not able to drain off properly. The combined effect do assume formidable proportions in the form of severe flood. There is often periodic fluctuation of water line in rivers on account of seasonal conditions and water take off for human needs. In India, of all the natural hazards, floods are the most distructive and they involve heavy expenditure on flood control and relief measures. The proneness to floods in North Indian plains increases from west to east.[36]

The non-periodic excess or deficit of water in any given regional environment giving rise in the Indian scene

35. The Times of India Directory and Year Book 1982.pp.99-100.

36. Kayastha S.L., "Floods in India: A study of their occurance, causes, forecasting and control," The National Geographical Journal of India, Vol. 29, part 3 & 4, Sept-Dec 1983, pp. 121-141.

to natural hazard has been investigat ed by some workers Abbi et al. (1975) have examined the relationship between rainfall and floods in India during the south west monsoon period of 1974 while Misra(1971) and chaturvedi (1975) discussed the flood problems of Marathwada and U.P. respectively. Arunachalam (1979) examined the causal factors underlying seasonal flooding year after year in Greater Bombay and pointed out that flooding is a natural phenomena, but the gravity becomes sometimes alarming as a result of unplanned human interference with the natural factors. Sikka (1973) discussed the norms and criteria for initiating scientific measurement of flood damages in M.P., through systematic mapping of area-slope charts, soil and land classificatory system. Sinha (1973) and Sikka (1973) highlighted flood routing and flood protection measures in the Gandhisagar dam and on the Narmada at Hoshangabad, through channel cont rol and on the basis of hydro-meteorological data analysis Kumaraswamy (1973) has developed a technique of flood warning tested to forecast floods in Tamil Nadu, through a hydrological-cum-mathematical model and VHF telemetry while Panjwani (1973) has designed peak flood computation for major multipurpose reservoirs on the Narmada. Ramachandran and Thakur (1972) have examined human perception and adjustment to flood hazard in the ganga floodplains.[37]

37. Arunachalam B. "water Resources of India," A Survey of Research in Physical Geography, ICSSR, New Delhi, 1983, pp. 125-141.

Nigel, W. Arnell (1984) finds that the National Flood Insurance Programme (NEJP) both provides flood insurance to floodplain occupants and encourages local communities to adopt flood plain land use regulations. As far as providing the core of the fedral non-structual flood hazard management effort is concerned the NFIP is a central element in both state and local activities. A major issue influencing the success of the NFIP in curbing flood damage is its treatment of properties built before the adoption of floodplain regulation. Revision of the regulations concerning the rebuilding of flood damaged properties would further assist hazard mitigation efforts.[38]

Churchill, R.R., and Hutchinson, D.M.,(1984) worked in Sri Lanka and viewed that in seeking a viable, longterm management policy, the Sri Lankan government recently adopted a plan to move the municipality of Ratnapura to invulnerable high ground, In making the decision to relocate, however, the attitude of the residents viewed relocation as an unacceptable solution to the problems. Although individual attitude concerning residential satisfaction in the context of the flood hazard varied with factors such as income, length of residency and land tenure, an overwhelming number of

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38. Nigel, W. Arnell, "Flood Hazard Management in the United States and the National Flood Insurance Programme," Geoforum, Vol. 15, No. 4, 1984, pp. 525-542.

residentsa adamantly maintained that they would not move to the new town.[39]

Mohan Dharia (1987) points out that though it may appear to be strange but the destruction of forests which has been the cause of drought is also the cause of devastating floods in the country. Due to the absence of trees and other vegetation there is no resistance and the waters which pour on the top of the hills flow down with all possible speed and velocity. The rains and the fast flowing water directly come in contact with the top soil already loosened by the sun and winds and carry the same to the river beds, dams and the sea. The deep river beds have been filled with the silt and have lost their earlier capacity to store the water. The water coming down from upstreams, naturally spreads all over the low level areas on both sides of the rivers and coverts itself into the devastating floods. Permanent prevention of floods and proper system to control them are move advisable than the yearly adhoc arrangements and heavy expenditure incurred in the most unplanned manner.[40]

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39. Churchill R.R, and Hutchinson D.M.,"Flood Hazard in Ratnapura, Srilanka: Individual Atitutdes VS collective Action," Geoforum, Vol. 15, No.4, 1984, pp.517-524.

40. Mohan Dharia, Afforestation in India, Pune 1987.

Chapter - Three

UTTAR PRADESH : RELIEF AND DRAINAGE

U.P. RELIEF AND DRAINAGE

In terms of area Uttar Pradesh is the fourth largest state in India and ranks first in terms of population. It is the only state in the country whose boundary line was not affected by the reorganisation of states that took place in 1956.

Uttar Pradesh is a land locked state lying between $23^{\circ}52'$ and $31^{\circ}18'$ N lat. and $77^{\circ}10'$ and $89^{\circ}39'$ E long. It is bounded by Tibet and Nepal in the north, Himachal Pradesh in the north west, Punjab Delhi and Haryana in the west, Rajasthan in the south west, Madhya Pradesh in the south and Bihar in the east. The river Yamuna forms part of the western boundary, the river Ganga part of the southern boundary and the river Gandak part of the eastern boundary of the state.

PHYSICAL FEATURES : The state is divided into four physical regions; the hill areas in the north along the Himalayas, a sub-montane tract comprising Bhabar and Tarai, the Yamuna Ganga plain with fertile alluvial soil, and the hill plateau region lying to the south of the Ganga plain The Himalayan tract in the extreme north comprises the

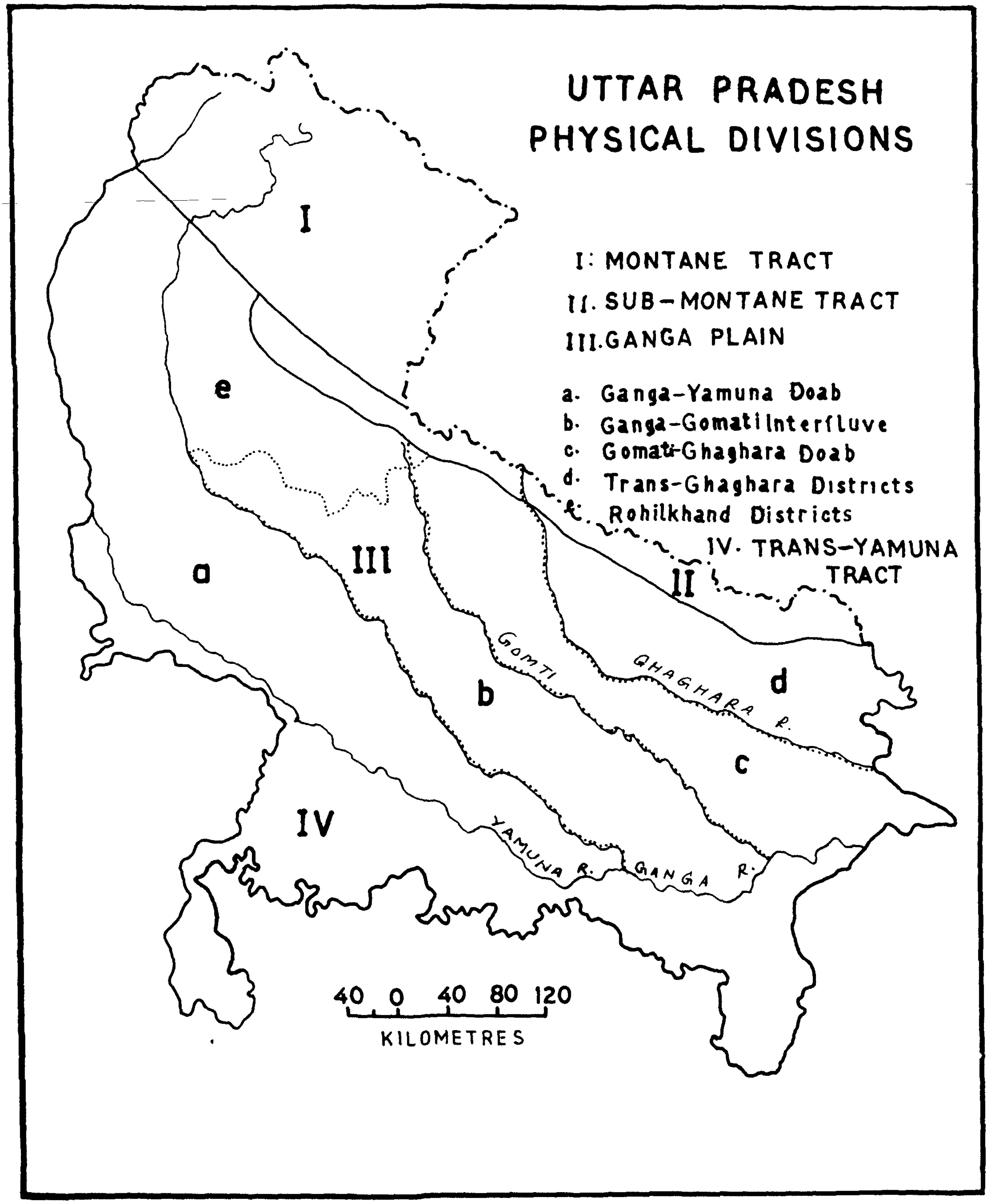
UTTAR PRADESH
PHYSICAL DIVISIONS
I: MONTANE TRACT
II. SUB-MONTANE TRACT
III. GANGA PLAIN
a. Ganga-Yamuna Doab
b. Ganga-Gomati Interfluve
c. Gomati-Ghaghara Doab
d. Trans-Ghaghara Districts
e. Rohilkhand Districts
IV. TRANS-YAMUNA TRACT
I
II
III
IV
a
b
c
d
e
GOMTI
GHAGHARA R.
YAMUNA R.
GANGA R.
40 0 40 80 120
KILOMETRES

FIG. 1

Kumaon Division and part of Dehra Dun district. This region is mountainous with some very high peaks (of which Nanda Devi is the highest, 7,698 metres). The snow clad peaks give rise to several rivers which carry silt to the plains rendering the land fertile for agriculture. These rivers provide a perennial source of irrigation and sites for generating hydel power.

The sub-montane tract between the Ganga and Sarda rivers has two distinct portions. Immediately below the hills lies a strip of land called the Bhabar (means porous). A large portion of Bhabar is covered with forest. Below the Bhabar is a wider strip of land called the Tarai, a damp and marshy tract covered for the most part with thick jungle and tall grasses.

The great Ganga plain is built up of the detritus (alluvial silt) from the Himalayas and is traversed by the rivers Yamuna, Ganga and Ghaghara, which run almost parallel to each other. The northern limit is marked by the smooth curve of the sub-montane tract, but on the south it is very irregular as the rugged surface of the south plateau intrudes into the smooth alluvial tract. The entire plain slopes generally from north-west to south-east.

In the south-west and south-east the two small tracts differ considerably from the plain in topographic details. The four districts (Jalaun, Banda, Hamirpur and Jhansi) in the south-west form part of the central Indian Plateau known as Bundelkhand region. This tract suffers from either an excess or a deficiency of rainfall. The tract in the south east conforms to the mirzapur district most of which is valleys, hills, ravines crags and has considerable deposits of limestone.

GEOLOGY :

An almost imperceptible change in elevation and uniform surface material are the two note-worthy features in the physiognomy of the region. Like its counterpart, the middle Ganga plain in the east, it also forms part of the alluvial filled asymmetrical Indo-Ganga trough with a definite divided formed by the subterranean Delhi Ridge, a protrusion of the Peninsular Block. The pre-tertiary river-borne debris from the peninsula latter supplemented rather more vigorously by the upper and post tertiary Himalayan debris, yet to undergo intense compaction, constitute by and large, the alluvial filling."Alluvium is one continuous and conformable series of fluviatile and sub-aerial deposits, mainly composed of unconsolidated beds of clay, sand, gravel and their mixture in varying proportions.[20] Oldham estimated the depth of the alluvium between 4000-6000 metres and Burrard considered the existence of a fault with 32 km down-through near the Himalaya. Later Glennie estimated the thickness at about 2000 m. The recent findings of the aeromagnetic survey of the Ganga valley[21] have thrown much light on the depth of the alluvium and nature of the trough. It rather replaces the hypothesis of the frontal plain by the downwarp. Though the alluvial filling on an average is 1300 -1400 m decreasing gradually southward, a zone of over 8000 m depth runs all along the Himalaya. The extensive pre-existing basins, such as Kathgodam Lakhimpur basin and Bahraich basin and similar others such as Gorakhpur and Motihari basins falling in the Middle Ganga plain and connected together with narrow necks, probably between the peninsular projections, have been indicated within the 8000 m depth zone. The westward decrease of the depth is well marked lying to the west of the Moradabad- Kathgodam alignment has less than 6000 m depth of the alluvium. The Doab south of Bulandshahr has, in general, less than 1500 m alluvial depth. Thus in the south the alluvial cover, gradually thins out to a mere veneer, finally merging with the irregular edge of the peninsular block. The alluvial depth is, at places

20. Mathur, R.N."Some characteristic features of water Table in Meerut District, U.P."N.G.J.I.VII(4 Dec.1961)pp.264.

21. Hari Narain," Airborne Magnetic surveys". Proceedings of seminar on earth sciences.Pt.I Geophysics(Hydrabad, The Indian Geophysical union 1965)pp.119-129.

less than 3000 m thick probably on the detached protrusions of the peninsular block as around Shahjahanpur and is less than 1500 m near Faizabad and Gonda. Although nearly half of the upper and middle Ganga plain lying roughly to the south of the Hapur-Etah-Unnao, Pratapgarh- Bhadohi-Ghazipur-Jagdishpur-Hajipur and Purnea alignment has less than 1500 m thick alluvial deposts. The subterranean crustal dislocations, the probable cause of the earth quakes, have also been identified more or less separating the aforesaid basins, notable being Moradabad-Kathgodam, Balamau-Kheri and Muzaffarpur East of Buxar. The constituents of lithology, ie. the Khadar, Bhangar and the gravels, are but the variants of the alluvium corresponding to their location and subsequent process is involved. The silt,clay and sand particles renewed annually occupy the reverian tracts (flood plains), whereas the Bhangar occupy the interfluvial zones above the general flood limits, the constituents experiencing slow and secular changes. The gravels of the Tarai and Bhabar zones are the loosely set sediments ranging from fine silt or clay particles to coarse sands, pebbles and sometimes even boulders and spread haphazardly in the zone of the break in slope at the foot of the Siwaliks, one distinctive character of the Bhangar is the formation of Kankar pans in the sub-soil zone through capillary action owing to the alternating calcareous sand and clay beds here as also elsewhere in the zone of seasonal rainfall, which adds to the soil moisture retention in the subsoil zone.

SOILS : In this region of almost uniform topography and lithology, the soils are by and large, homogeneous. The alluvial soils with the variants, the usar and bhur, depending on the drainage conditions, mechanical and chemical constitutents and the climatic characteristic are observed in different parts. The two common types the Khadar and Bhangar with different local names which sometimes stand for minute variations in properties, are quite widespread. The Khadar soils relatively rich in plant nutrient occupy the narrow frequent siltation tracts in the flood plains of the rivers. They are Neutral to alkaline in reaction (PH 6-8), are deficient in organic materials specially phosphorous and are sandy to loamy in texture. The Ganga Khadar soils have immature profiles with sandy to silty loam texture, lack of concretion, fair proportion of lime and other soluble salts and are alkaline in reaction (PH 8), with imperfect drainage. The Yamuna Khadar soils have sub-mature profile with predominance of clay and concentration of lime and other soluble salt contents under the poor drainage conditions. Even the Yamunapar Khadar also differs having mature neutral reaction (PH 6.8-7.2) under the restricted drainage conditions. Fertility is revived owing to frequent siltation.

In general the soluble salts and lime are low and show netural to slightly acidic nature except pH 6-7.5 in the lowlying areas prone to water logging. Illuviation is a common characteristics everywhere. In the proximity of the Ganga these are loamy to sandy loam in texture while near the Yamuna the silt content decreases giving sandy to sandy loam texture possibly due to excessive drainage.

Among the variants worth noting are the usar (reh) soil in a sizeable tract in the Ganga-Ghaghara Doab from Sultanpur, Pratapgarh, through Rae Bareli, Lucknow, Hardoi, Shahjahanpur etc, contiguous with the tract of the middle Ganga plain, caused by the efflorescence of sodium carbonate and sulphate under the alternating rainy and dry season, high water table and alkaline composition.

Another variant, the bhur, the sandy river deposit, is highly localised in Ramganga tract and in the narrow belt along the Ganga.

The submontane soil where two physiographic units, the bhabar and tarai are bedded with texturally different soils. The bhabar soil is sandy to gravelly, highly porous and aerated and has lower moisture retaining capacity, while the tarai zone is provided with rich clayey soil, with some proportion of fine sand, moisture and rich humus. The two zones are thickly forested. The deforestation in the Tarai is bringing considerable changes in the soil texture, humus content,etc.

GROUND WATER : The region is potentially quite rich in ground water resource, both free and confined. The confined aquifer (permanent water table) generally strikes between 60-90 m depth, while the temperory water table (free aquifer) depth is less than 30 m with wide spatial and seasonal variations. The information regarding the general occurrences is quite inadequate to explain the actual conditions. The free aquifer bears significant relationship with the relief, geological structure and existing water channels, as riverain Khadar tracts show, in general, lower water table which probably owes to seepage, which the heavy clay belts of the bhangar have higher water table. The canals, however, are the exceptions which add considerably in bringing the water table higher up as also in the punjab plain. A work in this field by a student of Geography is that of R.N. Mathur in the Meerut district, where about 20% of the observation wells show less than 3.3 - 10 m, the zones of high and low water table are highly localized as most of the first category wells are in the vicinity of the canals and those with lower water table are near the rivers, the Ganga, the Yamuna and the Hindon, Seasonal variations are well marked as also in other parts.

CLIMATE : Uttar Pradesh comprises only a small part of the subcontinent of India. Its climate can be understood better in the context of wind circulating systems prevalent in India and adjacent areas.

Broadly, India lies in the regimes of two great air current systems of summer and winter months known as summer and winter monsoons or south-west and north-east monsoons respectively when these winds reach the landmass the above mentioned direction can be noted, but when these winds reach Uttar Pradesh, the directions become south easterly and north-westerly , respectively. The summer monsoons enter Uttar Pradesh usually towards the end of June. Uttar pradesh gets most of its rainfall in summer, whereas the winter months bring a few showers from the north-westerly monsoons.

While studying the climate of Uttar Pradesh, temperature should be kept in sight as a factor since climate is the sum total of a series of weather conditions which include temperature besides pressure and other factors. The mean annual temperature in plains varies from 25°C to 26.6°C. In the foothills and hills of U.P., the mean annual temperature is about 13.3°C To the north of the isotherm 25°C which passes through Aligarh, Bahraich and Gorakhpur the temperature decreases as the altitude increases till we reach Dehra Dun which registers the lowest mean annual temperature in the plains. To the south of this isotherm the temperature does not show any appreciable decline, except in Jhansi and remains more or less the same in the central and southern plains of U.P.

The mean annual minimum temperature in the plains varies from 15.5°C to 20.5°C. The record for the hilly area is 10°C, whereas to the north of 18.3°C isotherm the temperature decreases as the latitude increases upto Dehradun. The mean annual minimum temperature of the southern and central plains of U.P. as recorded is 18.8°C.

The mean annual maximum temperature in the plains varies from 30.5°C to 32.7°C with 17.2°C in the hills. To the north of 31.1°C isotherm the phenomenon of decrease in temperature and increase in latitude is repeated till we reach DehraDun. There does not appear to be any appreciable change in temperature in southern U.P.

Rainfall : From the average annual rainfall of U.P. it is evident that it varies from 839 mm to 889 mm. The isohytes trend from north-west to the south east in an angular formation. From a detailed study of the directions of the isohytes, the following conclusions emerge :

i) The area of the lowest rainfall is bounded by a triangle formed by joining Delhi, Mainpuri and Agra in the west of U.P.

ii) The areas of heavy rainfall are (a) the hilly regions with rainfall above 110 cm and the southern border of the state with rainfall exceeding 100 cm.

iii) The highest gradient of rainfall variation is found to occur in western U.P. and the lowest gradient lies in a belt around Bahraich, Gonda, and Gorakhpur. An area of low gradient is Kanpur, Fatehpur, and Varanasi. The situation of these town will indicate that they are located on the bends of the isohytes making angluar curve.

iv) The two "baggy" areas of U.P., i.e. Jhansi and Mirzapur districts receive nearly the same amount of rainfall.

DRAINAGE : Rivers with their tributory system are the main channels of drainage of the land surface, they are at the same time also the chief agents of land erosion and sculpture and main lines for the transport of the products of waste of the land to the sea. Also drainage has to accomodate to the topography of the place.

In the extra-Peninsular area the drainage system owing to the mountain building movement of the late Tertiary age, is of much more recent development. The rivers here are not only eroding and transporting agents but are also depositing agents during their journey across the plains to the sea. The fact is that the drainage is not, in a large measure, consequent upon the physical features, or the relief. In other words many of the great Himalayan rivers are older than the mountains they traverse. The long-deep precipitous gorges of the Himalayas, cutting right through the line of the highest elevation are most characteristic features of the geography and are at once the best-marked results, as they are the clearest proofs of the inconsequent drainage of this region. From this the Himalayan drainage is called antecedent drainage.

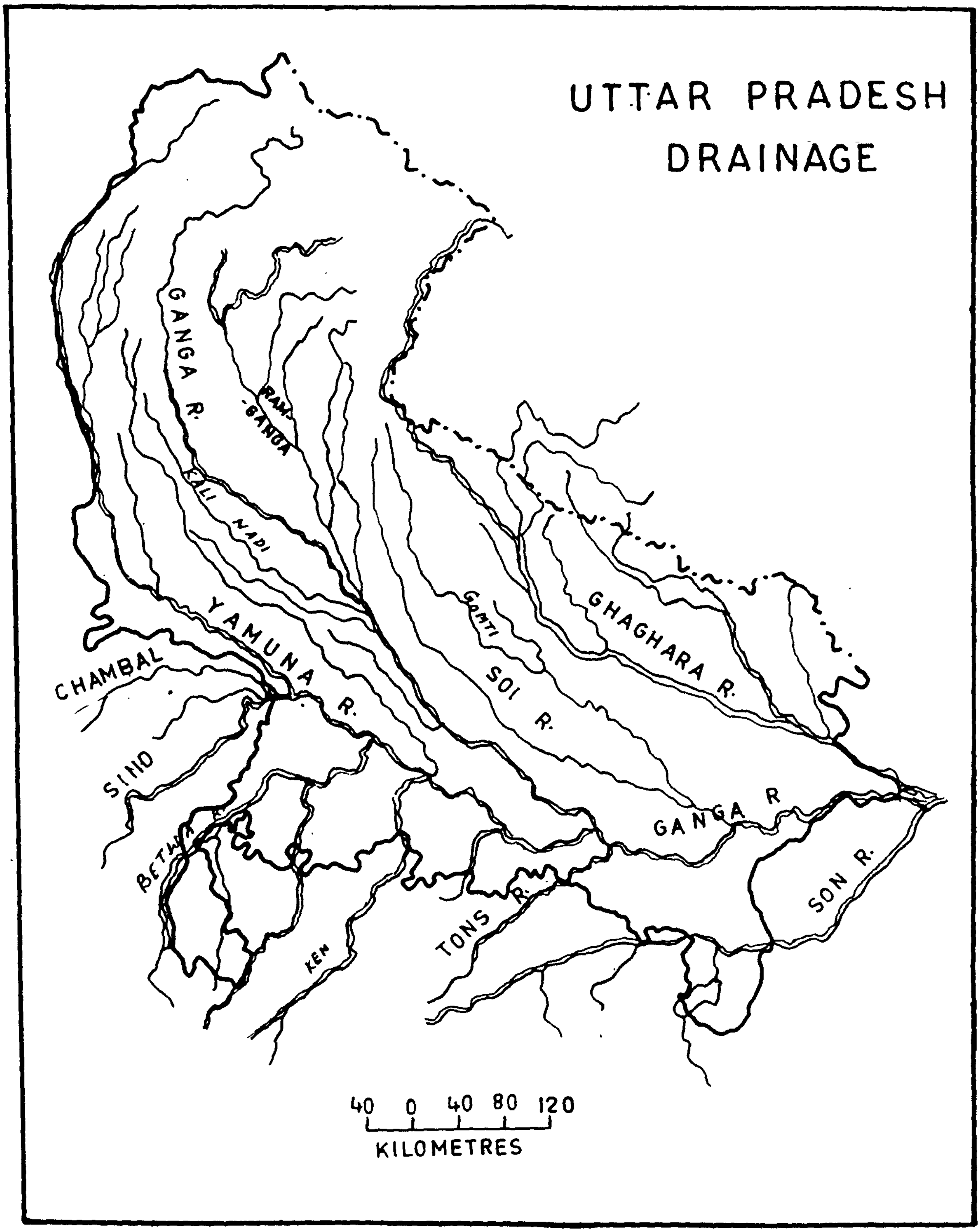
UTTAR PRADESH
DRAINAGE
GANGA R.
RAM-GANGA
KALI NADI
YAMUNA R.
CHAMBAL
SIND
BETWA
KEN
TONS R.
GOMTI
SOI R.
GHAGHARA R.
GANGA R
SON R.
40 0 40 80 120
KILOMETRES

FIG. 2

In the north and north-east the state is drained by the river Ganga and Yamuna and their tributaries. River Yamuna itself is the major tributary to river Ganga. Other tributories to the Ganga are the Ghaghara, the Sarju, the Sarda, the Rapti, the Gomati and the Ramganga, all of them emerging from the Himalayas. The rivers Gomati and Ghaghra are often in floods during the rainy season and cause serious damage to human life, livestock and property. Ganga, Yamuna and Ghaghra are used for navigation for long distances mainly for local traffic. In the south-west the drainage is through the rivers chambal, Sindh, Betwa, Ken and Sone all of which join theGanga or its tributaries. The Himalayan rivers are more active than those coming from the Vindhyan range in filling up the great plain with silt and they also provide more important source of irrigation and power since they have perennial supplies of water from monsoon rainfall supplemented by snow melts.

The Ganga basin with a drainage area of nearly 8,61,400 sq. Km in India covers slightly more than 1/4th of its total geographical area and is the biggest river basin in the country, sretching from Uttarkashi district of U.P., it covers the whole of Uttar Pradesh. The fertility of the Ganga plains in U.P. has been mainly due to the fine alluvium deposited by the rivers. The main rainy season of the basin is from June to September and accounts for 80-95 percent of the annual rainfall. The basin is so vast that the flood problem can be dealt with under various sub basins as follows :

The Yamuna basin extends over an area of 2,26,755 sq. km. It also covers large area of U.P. besides other states. The shape of the basin is irrigular. The important towns situated on the banks of the river are Delhi, Mathura, Agra, Etawah and Allahabad. The flood problem in the basin is not severe but still it submerges areas in U.P. The district affected by floods in U.P. area Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Banda and Allahabad.

The Ramganga basin extends over an area of 32,493 sq.km. The basin receives most of its rainfall during south west monsoon season from June to September. The Ramganga has a shifting and uncertain course in the plains. During floods, the river overflows its banks opening out new channels and destroys the fertility of the land by depositing coarse sand on it. The affected districts are Bijnor, Moradabad, Bareilly, Badaun, Shahjahanpur, Hardoi and Farrukhabad.

The Gomati basin covers an area of 30433 sq.km. and lies entirely in the state of Uttar Pradesh. It is roughly rectangular in shape. The basin is flat with a gradual slope from north-west to south-east. The important towns situated on the banks of the river Gomati are Lucknow, Sultanpur and Jaunpur.

The Ghaghara basin has a total catchment 1,27,950 sq.km. of which the area lying in India is 57,647 km. the rest being in Nepal. The river brings large quantities of silt during floods and deposits the same in its bed due to the poor bed slope and this results in the tendency to meander and consequent inundation of vast areas. The entire area on the right of the Ghaghara in the Azamgarh and Ballia districts is liable to inundation from floods.

PHYSICAL RESOURCE BASE : The total physical resource base in the region is confined to its rich alluvial soil and abundance of water resources in its long perennial rivers The two together can serve as the best ingredients for better development of agriculture. Relatively lesser instances of floods as compared to its counterpart, the Middle Ganga Plain and more assured water supply even at present through the canals account for its agricultural prosperity. It may be strengthened through further laying of more canal distributories and providing irrigation facilities to so far unirrigated lands. The hydel power generated from the water of the rivers will go a long way in furthering the

the rural electrification and will provide subsidiary Occupations to the villages by way of the development of agro-based cottage industries.

Further the forest resources of the tarai and the bhabhar can be used to develop forest, based industries on a large as well as small scale. There are no mineral resources other than glass sand and lime concretions. In addition the region has ample ground water resources which await survey and investigation. The oil and Natural gas commission is investigating oil resources in Tarai.

Though the upper Ganga plain is relatively more developed still it is having its own problems, Within this region there is much disparity in respect to economic development. The upper Doab being the most developed and Avadh Tarai being the least.

There have been misuse of land resources like ever grazing and deforestation in most areas and this has led to soil erosion and ravine formation and also has accentuated flooding and water logging, leading to imbalance in the eco-systems.

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Chapter - Four

UTTAR PRADESH : FLOODS - CAUSES, EXTENT, DAMAGE AND CONTROL

CAUSES AND EXTENT :

The state of Uttar Pradesh accounted for 24 percent of the total flooded area and 23 percent of the total damages in the country during the period 1971-1978. The eastern half of the state is more vulnerable wherein some area gets affected by floods almost every year. Eastern districts of Uttar Pradesh are most severly affected by the floods. The rivers which cause damage in this area are the Ghaghara, the Sarda, Gandak, and Rapti. The Ghaghara submerges an area of 7769.97 sq. km. and the Rapti about 3107.988 sq. km near the confluence of the Ganga and Ram Ganga. The problem of drainage congestion is also found in the western and north-western districts of Uttar Pradesh.

As at the National level, in the state too, there was a gradually declining trend in the extent of floods during 1956-65 which was reversed in 1966. Floods were more frequent and more severe during 1966-71, but the situation improved somewhat thereafter. Again the years 1976 and 1978 witnessed serious floods, of which that of 1978 was of unprecedented magnitude. These two floods brought about an upward trend in the total area affected.

The Himalayan rivers stand out as a separate class, the occurrence of floods in them is almost an annual

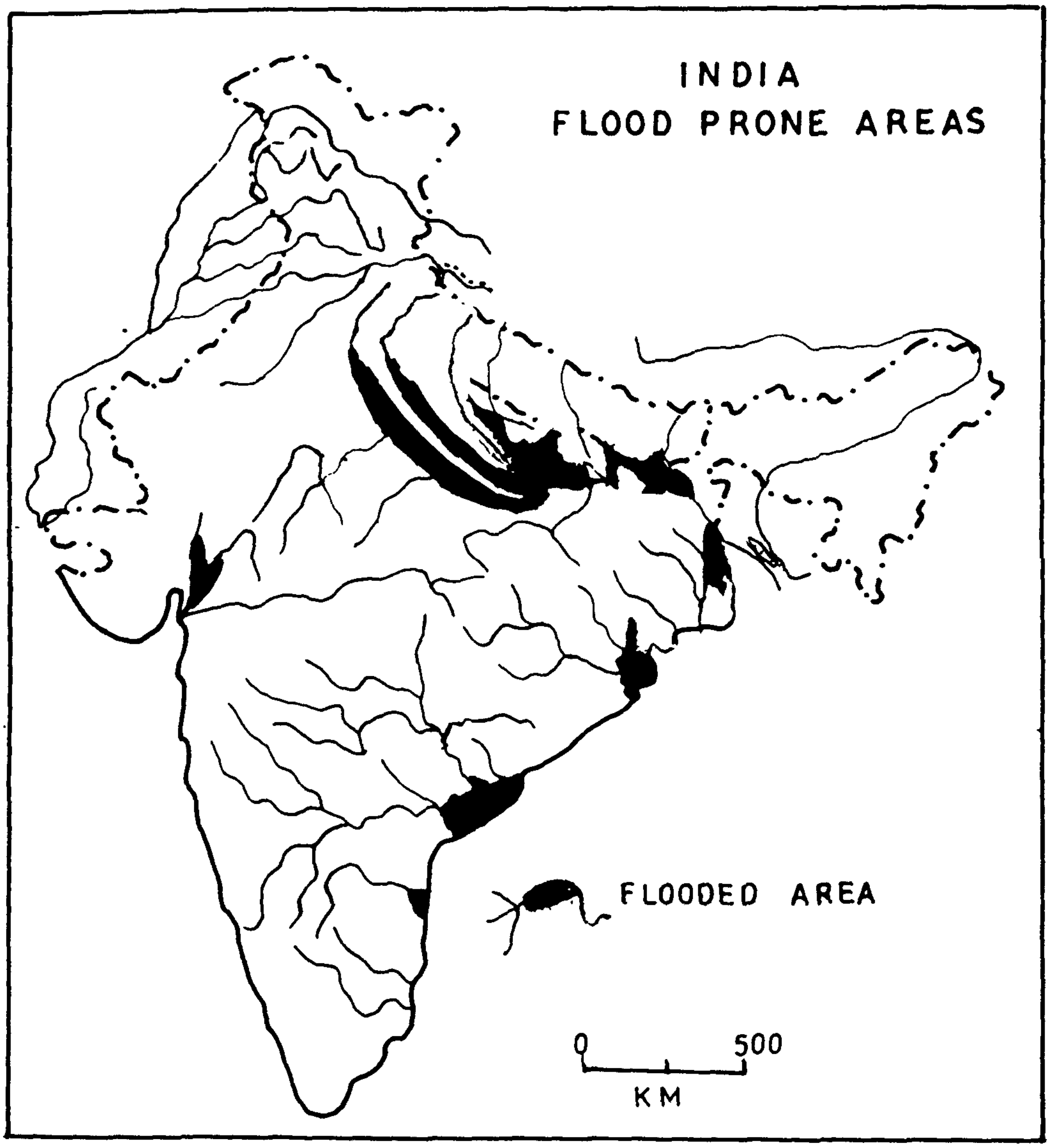

FIG. 3

phenomenon. The reason for it is heavy rainfall in the Himalayas, steep slopes of the rivers before they debouch into the plains and also absence of easy outflow facilities.

In Uttar Pradesh extensive riverine areas along the perennial rivers get annually inundated to varying depths. Most of such areas lie within the meander belt of the rivers in the Ganga plains. They are locally called 'Khadir' lands in western Uttar Pradesh and 'diara' lands in eastern districts of Ballia, Ghazipur, etc in the state. Due to continuous process of destructions and accretion or reformation by the river, the riverine land is often under dispute for ownership. Where the river meanders, the 'diara' land extends over a width ranging up to 12 km, but in straight sections of deep river bed, such land lies in the strips along the banks. Estimated extent of 'diara' land is about 15.41 lakh hactare along the Ganga, the Yamuna, the Ghaghara, the Sarda, the Ramganga, the Gomti and the Kalinadi. Table 1 shows estimated area of diara land along different rivers. According to the survey, it is seen that large percentage of the area of the district is under 'diara' in Ballia, Ghazipur, Allahabad, Farukhabad and Etah. According to topo-sequence 'diara' land is generally divided into three categories (a) low bank or Khadir region, (b) terai or slightly elevated mid-region and (c) trans-khadir or relatively flood-free upland. Cucurbits and other vegetables are grown in these areas. These categories among themselves vary in soil character and cropping pattern. For instance, Ghaghara 'diara' lands are calcareous and coarser in texture while Ganga 'diara' lands in the eastern end of the state are fine and clayey in texture. 'Diara' lands are free from floods for a short period which varies from 3 to 10 months. Table 2 shows the distribution of 'diara' area in selected districts of Uttar Pradesh.

Table - 1

Distribution of estimated area of 'diara' land along different rivers of Uttar Pradesh.

Rivers	Diara(lakh ha)
Ganga	4.08
Yamuna	3.98
Ghaghara	1.58
Sarda	0.72
Ramganga	1.73
Gomti	2.02
Kalinadi	1.30
Total	15.41

Table - 2

'Diara' area lying in 9 selected districts of Uttar Pradesh

District	Diara	Area(lakhha)
Meerut	18.8	-
Etah	103.4	(23.5)
Farukhabad	142.2	(23.5)
Kanpur	54.5	(8.9)
Allahabad	124.2	(17.0)
Mirzapur	17.5	-
Varanasi	14.9	(2.9)
Ghazipur	65.8	(20.7)
Ballia	165.6	(30.7)
Total	706.9	-

(Figures in bracket indicate the percent of the district as 'Diara' land)

Each river system has its own characteristic periods and causes of flooding. All river basins are prone to floods in view of the extreme variability of the monsoons but there are some basins like Ganga which are subject to serious floods every year. The core of the flood problem lies in the Ganga basin having 60% of the flood prone area in the country and 60 million hectares of cultivated area. Most of the catchments of river Ganga and its tributeries have, over the years, undergone degradation due to indiscriminate exploitation of forests, excessive grazing and faulty agricultural practices. This has led to the loss in retention capacity of the catchments and consequent increase in the run off and sediment flow which tends to upset the river regime and causes problem.

It is evident that increase in damage from floods is due to accentuation of floods on account of ecological damage, especially destruction of natural vegetation and unregulated explosion of settlements in the flood plains. It may appear to be strange but the destruction of forests which has been the cause of drought is also the cause of devastating floods. Due to the absence of trees and other vegetation there is no resistance and the waters which pour on the top of the hills flow down with all possible speed and velocity. So the water runs off the soil surface directly to the channels without being intercepted by vegetation, whereas formerly it was held in the root zone of the soil and allowed to infiltrate. In this way the rains and the fast flowing water directly come in contact with the top soil already loosened by the sun and the winds and carry the same to the river bed. The deep river beds have been filled with the silt and have lost their earlier capacity to store the water. The water coming down from upstreams, naturally spreads all over the low level areas on both sides of river and converts itself into the devastating floods.

A very remarkable cause of floods in these rivers is acute kink in the longitudinal profile. All the rivers issuing from these high mountains make an acute kink in their longitudinal profile at the junction of two contrasting slopes of steep mountains and the flat plain. In the upper mountainous course of Ganga stream from Gangotri 3139.44 metres) to Hardwar (304.8 metres) a sheer drop of about 2743.2 metres is noted in about 241.40 km making a very steep gradient of about 1:88, while along its course from Hardwar to Bay of Bengal the gradient is 1:7000 only. So in this way it is noted that the velocity and transporting power of streams directly depend on the gradient. So that rivers rushing down the steep mountains are suddenly slakened, their speed and power strangulated as soon they debouch on to the gentle plain. These mountain slopes are one of the rainiest regions recieving over 254 cm of rainfall annually, most of which i.e. 70-80 percent is concentrated in about three months from mid-June to mid-september. Added to this is summer melt water of snow and ice. The heavy downpour on the rivers during the wet season is easily discharged in the mountainous course due to steep gradient, But when the avalanche of water plunges on to the flat valleys of the plain, the slope is inadequate to cope with this emergency discharge and water spreads submerging low lands under floods.

Because of the sharp kink in the longitudinal profile, the rivers transporting down huge load of sediments from the mountains fail to do so efficiently on the plain and hence deposit them in their valleys. In certain cases the amount of debris is so huge that piedmont alluvial cones and fans are built. The river Kosi, which is so notorious for her disastrous floods has been building a vast cone debris about 160.93 kms long with its apex at Chatra, just outside the mountain range and the base along Ganga. In this way rivers get shallow and are unable to drain away the flood water and become liable to change paths not infrequently. The Kosi river has been moving westward for about some years.

Almost all the Himalayan rivers flowing on the northern plain have only one common exit, i.e. the River Ganga. During the wet season when these tributaries bring down the enormous amount of rain water, their mouth is choked by the already swollen main river causing over-flows and floods.

An important feature of monsoon rainfall over the state is its great concentration in short period of the year. It is noted that 70-75 percent of rainfall annually is concentrated within only 23 to 36 days. Agra for instance with 68.07 cm of annual rainfall receive 80 percent of it i.e. 52.8 cm in a short duration of only 23 days. Similarly the situation becomes worst when there is exceptionally heavy downpour in the course of a few hours or a single day. Sometimes such exceptional but copious rainfall extends over thousands of square kms persisting for two to three days continuously. The districts like Allahabad, Saharanpur, Muzaffarnagar, Bijnor, Meerut, Moradabad and Pilibhit have been recording such rainfall for long span of time. Thus in this case it never rains but pours on these plains. Therefore sudden release of copious water swells the rivers into floods as the river cannot drain away unexpected and profuse water supply in so short a time. The problem in such type of down pour that creeps up is, ground is already wet and does not reduce the run off by soaking and also the evaporation is less due to high humidity and cloudiness, all the conditions do favour floods.

Another reason for floods in this area is that lakes are practically absent due to which its function as safety valve during floods by absorbing the excess water is absent.

Meanders greatly retard the velocity of the stream by interlocking spurs formed between the curves. So that

EASTERN U.P.: MEANDERING NATURE OF THE MAJOR RIVERS

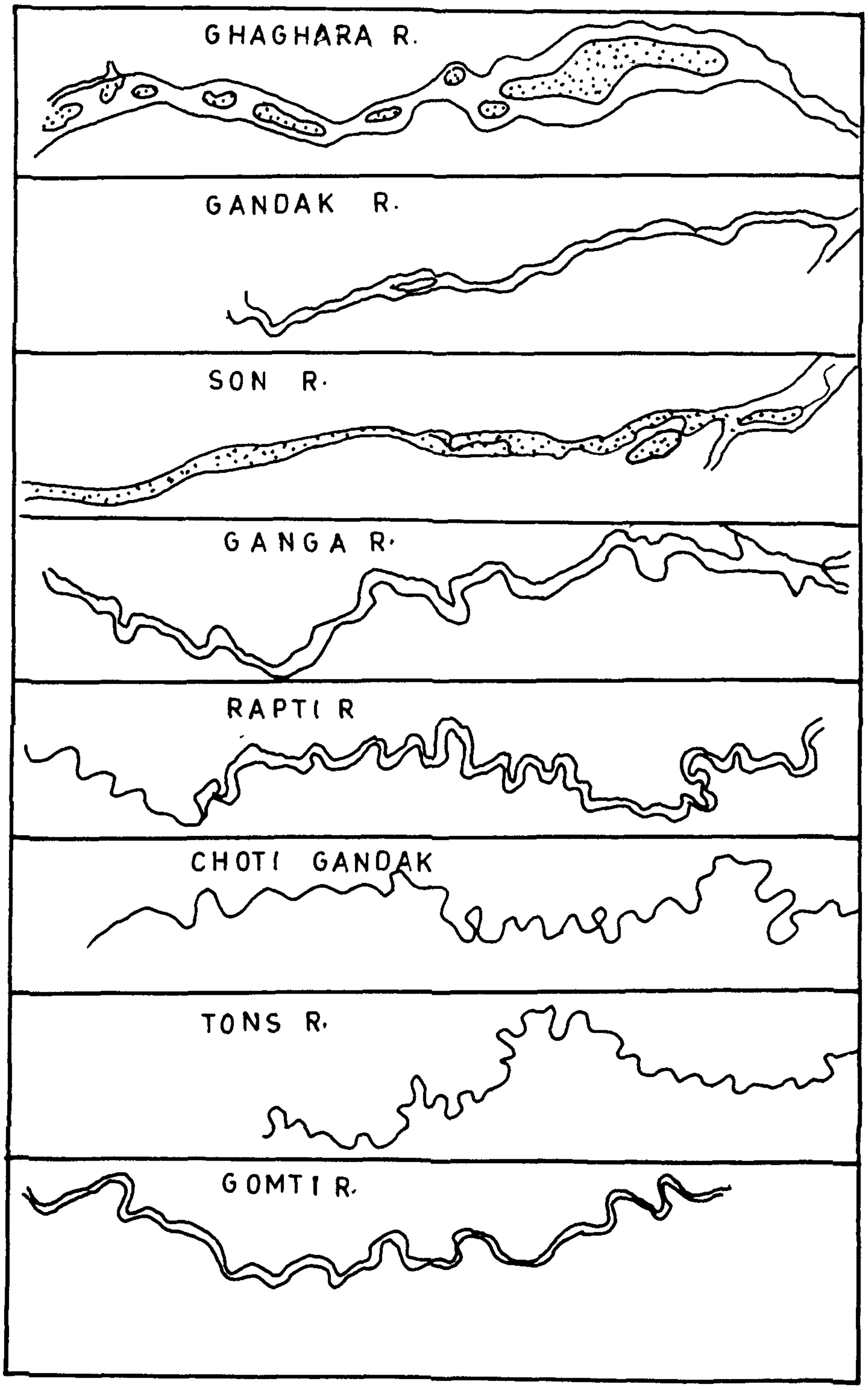

FIG.4

whenever there is heavier supply of water due to excessive rainfall or melting of snow, the tortuous course with jutting bluffs constrict the discharge and water overflows on to the plains. Fig (4).

Yet another problem is that Himalayan rivers are subject to occasional catastrophic floods due to landslides in their upper courses on the steep mountains. They flow through deep gorges where a big landslide may dam up a huge reservoir. Sooner or later this temporary embankment collapses, releasing vast quantities of flood water. A very old example of it is the great flood in Garhwal in 1894, which were caused by a huge landslide which completely blocked the valley of river Bireh Ganga to a depth of 243.84 metres.

The extensive high Himalayas are probably the only exception in the world which have a broad and vast low land against the windward steep slopes. Due to this all the rain water spreads through the sluggish and hyperbolic rivers for thousands of Kilometres, first on the flat land, before draining into the distant sea. Added to this is the problem of flood-water discharge contributed by the southern tributaries into the same trough like receptacle of the Ganga plain. Thus any excessive rainfall is bound to flood this synclinal basin between the mountains and the sea.

Human factors further contribute to the rivers propensity for flood besides physical factors. It is a fact that ruthless distruction of forests on the Ganga plain to satisfy the needs of ever growing population has had its repurcussion through floods. Natural vegetation specially forests regulate and retard the surface run off and soak the rainwater in the roots. The foliage also absorbs certain amount of rainfall at time of drip down. Soil erosion is thus checked which would have silted a river causing frequent overflows.

Flooding is a natural phenomena which enables the rivers to develop their flood plains. The marked seasonality of rainfall and its torrential nature makes the situation highly flood prove. It would be interesting in this regard to refer to a newspaper report from Delhi entitled 'Downpour throws city out of gear.' It says that the first heavy rain of the season in Delhi on 29 and 30 June, 1981 washed away a myth about the local administrations capacity to face the floods efficiently and the much publicized claims about full preparations to meet monsoon went down the drain.[1] Report from Mainpuri town of Uttar Pradesh, stated that in a single day on 29 June 1981, 23.5 cm rain fell, causing extensive damage to property.

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1. Report, Downpour Throws city out of Gear, The Statesman, New Delhi, Dt. 1.7.81.

DAMAGE : Since the initiation of flood control programme in 1954, considerable progress has been made in protecting areas from floods. The amount yearmarked has also increased in successive plans. Large scale floods have occurred in Uttar Pradesh in 1978 and 1971 when a total of 52.6 lakh hectares were affected of which 26.5 lakh hectares were under cultivation. A number of districts, particularly in the eastern region of the state were affected. The more severely affected among them were Bahraich, Gonda, Basti, Sitapur, Barabanki and Varanasi which together accounted for 36 percent of crop areas submerged in the state. Damage by floods during 1980 in Uttar Pradesh was 5.857 million hectare in terms of area and 30.347 million population was affected, where as 1,309 human lives were lost. Similarly in 1981 the situation was that floods effected 3.0 million hectare of land, 14.6 million population and 427 human lives were lost which is less than the previous year but in 1982 it was 5.5 million hectare of land effected, 23.3 million population and 562 human lives were lost so it shows a rise in damage again. Table 3(A) shows the trend of area affected by floods and table 3(B) shows damages since 1953 to 1978 in Uttar Pradesh.

TABLE-3

Uttar Pradesh : Trend in area affected by Flood and damage.

A : Area affected (Lakh hectares)

Year	Crop area annual	non-crop area annual	Total annual
1953	NA	NA	9.1
1954	7.4	6.1	13.5
1955	25.7	15.6	41.3
1956	9.3*	15.7*	25.0
1957	6.3*	10.7*	17.0
1958	8.1*	13.7*	21.8
1959	Neg	0.7	0.7
1960	5.9	26.6	32.5
1961	2.2	20.7	22.9
1962	10.6	Nil	10.6
1963	12.0	0.6	12.6
1964	7.7	2.9	10.6
1965	Neg	0.8	0.8
1966	2.8	2.4	5.2
1967	15.2	19.1	34.3
1968	4.0	4.0	8.0
1969	13.1	10.9	24.0
1970	17.0	12.1	29.1
1971	26.5	26.1	52.6
1972	1.8	1.3	3.1
1973	15.0	11.3	26.3
1974	9.0	4.5	13.5
1975	13.8	8.0	21.8
1976	21.6	14.7	36.3
1977	6.1	6.9	13.0
1978	39.3	34.1	73.4

* Figure estimated
NA - Not available
Neg- Negligible

B : Damages at constant (1952-53) prices
(Rs. in lakhs)

Year	Crop damage annual	non-crop damage annual	Total damage annual
1953	1026.57	199.62	1226.19
1954	700.21	169.68	869.89
1955	3028.70	319.13	3347.83
1956	2126.73	691.33	2818.06
1957	982.50	482.15*	1464.65
1958	1094.59	167.84*	1262.43
1959	Neg	1.21*	1.21
1960	726.00*	376.08*	1102.08
1961	265.91*	23.61*	289.52
1962	1571.97	100.24	1672.21
1963	1443.69	241.28	1684.97
1964	748.70	21.85	770.55
1965	6.68	1.24	7.92
1966	364.01	48.03*	412.04
1967	2512.48	286.20	2798.68
1968	386.78	24.87	411.65
1969	1486.30	182.39	1668.69
1970	1731.78	1163.25	2895.03
1971	4414.86	2850.39	7265.25
1972	109.39	103.44*	217.83
1973	2081.91	476.22	2558.13
1974	1376.99	1256.84	2633.83
1975	758.69	206.51	965.20
1976	5027.03	1624.54	6651.57
1977	1745.00	514.16	2259.16
1978	8975.56	4279.65	13255.21

* - Estimated Neg - Negligible

Source : Basic data furnished by Central Water Commission

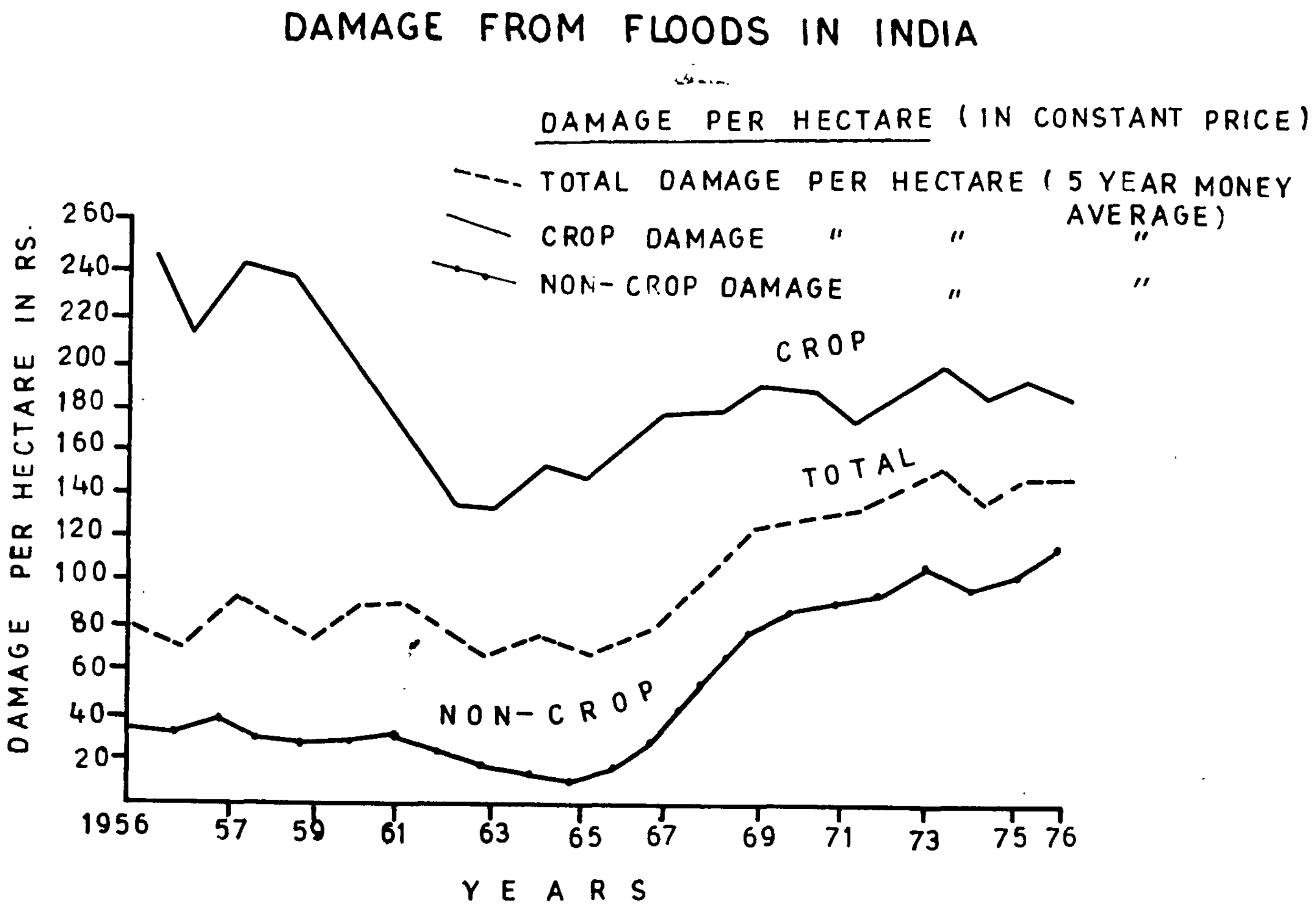
DAMAGE FROM FLOODS IN INDIA
DAMAGE PER HECTARE (IN CONSTANT PRICE)
TOTAL DAMAGE PER HECTARE (5 YEAR MONEY AVERAGE)
CROP DAMAGE " " "
NON-CROP DAMAGE " "
DAMAGE PER HECTARE IN RS.
260
240
220
200
180
160
140
120
100
80
60
40
20
CROP
TOTAL
NON-CROP
1956
57
59
61
63
65
67
69
71
73
75
76
YEARS

FIG. 5

CONTROL : Flood control should not be considered as an end in itself, rather it is the means to an end. Flood control has to be viewed within the broad context of the economic and social development. Management of floods should be considered in the context of the overall plan for management of the water resources of a river basin.

In Uttar Pradesh an additional chief Engineer (Planning) is in charge of overall planning of irrigation and of flood control works. He is assisted by one superintending Engineer at headquarters for planning and examination and two in the field for investigations and construction of flood schemes. The circles in charge of irrigation works also investigate and execute flood schemes falling in their jurisdictions.

It is quite true that flood cannot be controlled. What one can do is regulate the flow of water as far as possible, within the river and its channels so as to minimize the extent of damage.Measures to affect this are biotic, engineering and administrative in nature. Studies have shown that rainwater takes about 12 hours to reach the ground and about 48 hours to reach the water course. In this process the soil is saturated and water trickles. The rush and violence of water is not there, thus avoiding the quick peak flood formation conditions the accelerated erosion and sedimentation. Deforestation tends to increase total stream flow and alter the balance between peak and base flow. Uttar Pradesh is the victim of self reinforcing spiral of environmental deterioration. The frequency and intensity of floods has increased mainly due to uncontrolled exploitation of forests in the Himalaya.

For prevention and control of floods, the engineering measures include construction of flood control and flood protection works like detention reservoirs, embankments, river training, town and village protection and drainage schemes. Engineering measures should be supported by better landuse so that it may not create problems like faster siltation. The effectiveness of reservoirs in moderating floods would depend upon the capacity available for absorbing flood runoff. Because of high cost, reservoirs should be made for multi-purpose, with flood moderation as one of its function. Permanent water bodies like beels and lakes could be developed for pisciculture and aquaculture and also used for flood moderation where feasible. A large proportion of the rainfall infiltrates into the ground and maintains soil moisture and ground water. To the extent that the infiltration is increased, the direct surface runoff is decreased. A substantial part of the rain water, which inflitrates into the soil, is used up by evaporation or evapo-transpiration, and does not appear as surface runoff. Part of the water which percolates into the ground water zone reappears as surface water in springs and streams, mostly after the peak of the flood runoff has passed, Measures for increasing ground water recharge are, therefore, conducive to reduction of flood runoff. This may be in the form of land management for water conservation, water spreading, water harvesting structures, recharging wells etc. The capacity of the natural drainage system is seldom enough to safely carry large flood flows. Measures like embankments, channel improvements, emergency floodways, river diversions and interbasin transfers may be adopted.

The administrative measures are primarily disaster prevention measures aimed at minimise loss of life and property by planning in advance. Such measures are flood farecasting and flood warning, flood fighting, evacuating, community shelters for people, and raised shelter platforms. It is also suggested that insurance be introduced to people, agriculture and industries which suffer from floods.

A further aspect of flood plain management involves consideration of alternative ways of adjusting to floods, either by propecting installations on the flood plain, by adjusting activities to cope with floods, by evacuation or by local authority zoning of the floodplain to prevent high-value structures and materials from being placed in potentially inundated areas, Cities have spread into flood plains and cause encroachment during high flood level producing real flood hazard.

It is not possible to control floods in its real sence but by controlling of flood it means to minimize it to greater extent and to reduce the losses through afforestation, bunds, percolation tanks, digging the river beds and disciplining the rivers. Permanent prevention of floods and proper system to control them are more advisable than the yearly adhoc arrangements and heavy expenditure incurred in the most unplanned manner.

CONCLUSION AND WORK TO BE DONE

Floods have become a part of life for the people. They try to adjust with it because of the fact that floods cannot be stopped but can be controlled to a certain limit. Water plays havoc in the form of floods and becomes a source of sorrow for people damaging their crops, animals and other property. The enormous deposition of silt and detritus, concentration of run off, periodical changes in river beds, choking of river courses, etc create problems to all walks of life whether it may be agriculture, industry or life itself.

The phenomena of floods is not new, but it is felt more now as there is rapid increase in population and in the all round activities which need land. Flood protection measures on a limited scale were undertaken in India from early times. Governmental interest in the problem developed chiefly during the past century, when a number of well planned embankments were constructed on some of the rivers, which were causing recurrent flood damage. Since 1954, the central and state governments have appointed a number of committees to study and advise on the policy matters for the speedy implementation of the flood control and also to examine flood problem in general.

About 40 million hectares of land which is about one eights of the total geographical area of the country is prone to floods. The major flood prone states are Bihar, Uttar Pradesh, and West Bengal. Floods were also significant in Andhra Pradesh, Gujrat, Haryana, Kerala, Jammu and Kashmir. Damages caused by floods to crops, houses and public utilities during the past 32 years were maximum in 1983 amounting to Rs.24,599.7 million, the highest for any year in memory. As many as 3,275 human lives were lost and 153,086 cattle perished. The maximum loss was registered in Andhra Pradesh, valued at Rs. 6230 million.

In Uttar Pradesh most affected districts are in the eastern part. The rivers which cause damage in this area are the Ghaghara, Gomati Ganga and Rapti. Inundation also occurs, as in the current years, near the confluence of the Ganga and Ram Ganga and also in the upper reaches of Bari Gandak. The state of Uttar Pradesh accounted for 24 percent of the total flooded area and 23 percent of the total damages in the country during the period 1971-78. The eastern half is more vulnerable where some part or the other is affected by floods almost every year. The proportion of cropped area in the total area affected increased from 45 percent during 1953-65 to about 55% during 1971-78. Floods were more frequent and more severe during 1966-71 but situation improved somewhat thereafter. Again the years 1976 and 1978 witnessed serious floods, of which that of 1978 was of unprecedented magnitude. These two floods brought about an upward trend in total area affected. One peculiar feature of the overall situation in Uttar Pradesh was that if the 1978 floods were to be ignored there was no marked difference between the pre 1965 and the post 1965 position in respect of the extent of area affected. The trend in damages increased mainly due to increase in damage of crops and property during 1971, 1976 and 1978 In 1971-78, a total of 52.6 lakh hectares were affected of which 26.5 lakh hectares were under cultivation. A number of districts particularly in the eastern region of the state were affected. The more severly affected among them where Bahraich, Gonda, Basti, Sitapur, Barabanki and Varanasi which together accounted for 36 percent of crop areas submerged in the state. The annual growth rate of agricultural output during the period in Uttar Pradesh was in the range of 0.1 to 1.9% in eastern districts of Uttar Pradesh, while western districts like Aligarh, Muzaffarnagar, Meerut, Bulandshahr and

Mathura recorded growth rates ranging from 4.41 to 6.47 percent.

In 1980 flood waters of Ganga and its tributaries seriously affected 46 districts of Uttar Pradesh. It was due to heavy rainfall and drainage congestion. The recorded number of deaths in Uttar Pradesh was 1309 being largest in the country and total population that was affected was 30.347 million and area affected was 5.857 million hectre. In 1981 also Uttar Pradesh recorded the largest deaths being 427 area affected was 3.0 million hactre and total population affected was 14.6 million.

PROPOSED WORK : The taskof water management in flood prove areas needs in depth investigations, data collection and validation, data analysis with the help of analytical tools to facilitate quantitative modelling through use of data stored in the information system with a view to arriving at some optimal solutions which would prescribe some form of diversion and storage. This would be adopted to even out the flow and also to conserve our precious water resources for use in water-short regions and during dry seasons.

In a study of the flood hazard, there is need to consider meteorological factors, such as the incidence of heavy rainfall, hydrological conditions such as catchment characteristics and also human hazard producing factors. The meterological conditions leading to flooding involve intense precipitation, prolonged precipitation or snow melt, either singly or acting in combination. Frequency of rainfall also plays an important role. The character of the catchment will determine the response to heavy rainfall and the effect of some physical catchment parameters, which helps in flood intensification such as basin network and channel characteristics. For this shape is one of the most important factor, geology, soil type and vegetation variations are also important variables. Surface run off also accounts for it.

In contrast with records of annual or monthly values of mean run-off, flood occurrances may be treated as random event, for the meteorologic and hydrologic factors affecting flood production do vary with time sufficiently that the combinations have many characteristic of chance events. For example if in a period of 20 years of record the largest flood recorded was of a certain size it is probable that the next 20 years will also contain a flood of equal magnitude.

Simple procedure for computing flood frequency had been used. The most practical way is tabulation of the highest discharge in each year of record at the station. Momentary peak discharge are used for this, if available, The sample then includes only one event in each year. The mean of this series is called the mean annual flood. The plotting position for individual items in the array is determined by the formula :

$$\text{Recurrence interval} = \frac{N + 1}{M}$$

where N equals the number of years of record and M is the rank of the individual item in the array. Such data for an individual station are usually plotted on logarithmic probability paper.

Because there are differences in the flood experience even in neighbouring streams and because in flood potential that exist among lithologic and topographic types, it is necessary to generalize flood experience over geographic area. This is done by plotting graphs by taking recurrence interval in years on x-axis and discharge, in ratio to mean annual flood on Y-axis.By using this factor, flood experience of area of various sizes and length of record may be grouped on this basis of similarity in such curves, geographic areas are delineated that have comparable flood potential. Flood frequency compila- tions and analyses yield values of a parameter recurrence intervals. This is the average interval of time within which a flood of a given magnitude will be equal or exceeded,but once.

The flood potentials of different regions can also be compared by using drainage basins of equal size as units of comparison.

For all these purposes study shall be based on published data from various government agencies, censuses and district handbooks. The study shall be pursued on district level. This study is aimed to take into account various factors which cause floods and to propose methods to reduce a if not stop them.

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